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ADVANCES IN SEWAGE TREATMENT IN THE PERIOD FROM SEPTEMBER 1, 1952 TO OCTOBER 1, 1954

Progress Report of the Committee
of the Sanitary Engineering Division on
Sewerage and Sewage Treatment

SANITARY ENGINEERING
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ADVANCES IN SEWAGE TREATMENT IN THE PERIOD FROM SEPTEMBER 1, 1952 TO OCTOBER 1, 1954

Progress Report of the Committee of the Sanitary Engineering Division on Sewerage and Sewage Treatment

This report of the Committee on Sewerage and Sewage Treatment covers a period of approximately two years, from September 1, 1952 to October 1, 1954 —during which for the first time in ten years the country became more or less free of war-time restrictions. Certain relaxation of construction restrictions became effective January 1, 1953, and they were further eased on July 1, 1953 (1).

This period saw the realization of much needed research facilities in the dedication of the new Robert A. Taft Engineering Center for the United States Public Health Service (hereinafter styled USPHS) in Cincinnati in April 1954, and the construction of the new Lawrence Experiment Station in Massachusetts, placed in service in February 1954, replacing the old station which had sponsored much of the pioneer work in the field of water and sewage treatment since 1886.(2)

Easing of the municipal bond market helped stimulate construction. Plants for sewage treatment were generally of conservative design and followed a post-war trend toward more secondary treatment, chlorination of effluents, high-rate trickling filter installations, and growth of the activated sludge process in all its modifications.(3),(4) Perhaps the outstanding development has been the attack on the high cost of sludge disposal by improvements in the concentration, digestion, and vacuum filtration of sludge. There has also been emphasis on increased loadings in biological treatment processes. Industry was active in developing methods for treating its industrial wastes.

The annual review of the literature on sewage, waste treatment and water pollution by the Committee on Research of the Federation of Sewage and Industrial Wastes Associations,(5),(6) continues to summarize the art, principally from the research, laboratory, and operating standpoints, as has been done each year since 1933. The 1953 review covered a record number of articles: 64 on analytical methods; 166 on sewage treatment; 59 on radioactivity; 191 on industrial wastes; and 256 on water pollution—a total of 736 references. The literature reveals refinement of old processes and techniques but perhaps not enough basic research leading to new concepts and processes. Among the developments are the realization that higher loadings in biological processes can be attained with higher oxygenation capacity and improved oxygen transfer; further attention to sewage lagoons, oxidation ponds, and irrigation methods; and the improved sludge disposal methods.

The Federation Committee Reviews for the years 1952 and 1953 occupied a total of 177 pages and are most comprehensive from the standpoint of the literature. This ASCE report is directed chiefly to the engineering phases of the art and to topics which are authenticated but not always published.

A general discussion (7) of the public health importance of water supply and waste disposal work has been presented by D. A. Okun, A.M. ASCE, including control of communicable diseases such as typhoid, gastroenteritis, amebiasis,

cholera, infectious hepatitis and other diseases which are or may possibly be transmitted through water, such as schistosomiasis, tularemia, tuberculosis and poliomyelitis. He emphasizes the importance of control of toxic compounds as well as metals, metal salts, and miscellaneous poisons, including the effect of sodium and radioactivity.

Pollution Reports and Surveys

Sewerage and Drainage of the Greater Vancouver Area, B.C.

A Board of Engineers, C. G. Hyde, Hon. M. ASCE, J. C. Oliver, M. ASCE, and A. M. Rawn, M. ASCE, has issued a report[8] on this 32 sq. mi. area with a total population in 1951 of 520,313 and an average allowance of 139 (Imp.) gals. per cap. per day. Eight outfalls are suggested for discharge of the sewage but treatment will be required at only two of these. The report recommends that a joint agency be created to finance, construct, and operate the facilities recommended and to distribute the total annual cost to each of the political entities.

Seattle, Washington

The Washington State Pollution Control Commission has issued a bulletin[9] on the sewage disposal problem in the Seattle Metropolitan area including 124 sq. mi. of suburban Seattle with a 1950-51 population of 182,000. The total metropolitan area covers 296 sq. mi. with a 1950-51 population of about 670,000. The Commission recommends the preparation of a master sewage disposal plan for the metropolitan area, the strengthening of sewer district laws, and the formation of a metropolitan sanitary district. Existing sewerage is unsatisfactory.

R. W. Finke, M. ASCE, Seattle City Engineer, presents a plan[10] for the complete modernization of the present sewer system over a ten-year period at an estimated cost of $25 million, including intercepting sewers, pumping stations, and sewage treatment works. The plan divides the city into four drainage areas, two of which would be provided with primary treatment with the raw sludge to be disposed of in deep water. The plant effluents would be chlorinated. One of the other drainage areas would be provided with primary treatment and sludge digestion while the treatment plant for the fourth drainage area would also be provided with aeration facilities. Currently there is disagreement between different city officials and the State Pollution Control Commission as to the type and degree of treatment which should be provided for Seattle.[48] In the meantime, beaches in the area will continue to be closed to swimmers.

Lower Columbia River Basin

The lower Columbia River Basin needs 119 municipal and industrial pollution abatement projects costing an estimated $11 million, according to a joint State-Federal survey[11] made by the USPHS, the Oregon Sanitary Authority, and the Washington Pollution Control Commission, noting that corrective measures have already been taken at 82 of 201 sources of pollution in the area covered by the survey.

Water Quality Criteria

The California Water Pollution Control Board has prepared a compilation of all known standards of water quality.[12] This is a monumental piece of

research, with the objective of assembling, condensing and evaluating the literature pertaining to water quality. The report includes sections on dilution and mixing in surface streams, analysis of stream flow data, self-purification, biological indices, dilution in ocean waters, and dilution and self-purification in ground water. The bulk of the report consists of summaries of literature relating to threshhold and limiting concentrations for each potential dilutant with respect to each beneficial use of water. These data are presented according to beneficial use and by an alphabetical listing of potential pollutants. The summary and conclusions contain the significant recommendation that the California "Water Pollution Control Boards make no attempt to establish tabulations of water quality standards and that each problem of water pollution be studied and evaluated separately in the light of local conditions, the many variable factors that affect pollution, and the data contained in this compendium of criteria."

J. E. McKee, M. ASCE, and V. W. Bacon, A.M. ASCE, present an analysis of water quality criteria [31] with arguments for the "case by-case" approach to pollution control problems as compared with fixed water-quality standards or effluent standards. The principal advantage of standards of stream quality over effluent standards lies in the fact that they take into account dilution and the assimilative capacity of the receiving water and consequently lead generally to an economy of treatment works for pollution abatement. On the other hand, such standards are more difficult to formulate and define and to administer than effluent standards. The use of stream standards or effluent standards may result in possible inequities because of the fact that many variables other than the strength and volume of the waste influence the effect of the pollution, and case-by-case consideration is preferable. As of January 1952, only three states had adopted state-wide effluent standards and seven states had adopted state-wide water-quality standards. The majority of the states have avoided the use of any rigid state-wide standards, preferring instead to make case-by-case studies of each problem based on the beneficial use of the water involved and the general economy of the region being considered.

In discussing this analysis, T. R. Camp, M. ASCE, is of the opinion that both stream water-quality standards and effluent standards must be used in any equitable abatement program. He believes the pollution control agency should establish effluent standards in terms of limiting pollution loads at each point of pollution so that the water-quality standards for the stream will not be violated. The polluters are entitled to a rational allocation of the pollution-receiving capacity of a stream. Control agencies should establish limiting pollution loads at each point of pollution and should reallocate loads when other riparian owners wish to produce liquid wastes. J. R. Snell, A.M. ASCE, believes that stream quality standards are preferable for most states. E. W. Steel, M. ASCE, appears to favor the case-by-case approach.

The problems of water pollution control policy have also been presented by P. D. Haney, M. ASCE.[32]

San Diego County

A comprehensive report dated September 2, 1952 on the sewage disposal problem for San Diego County, California (13), (14) has been prepared by a Board of Engineers, David H. Caldwell, A.M. ASCE; Charles Gilman Hyde, Hon. M. ASCE; A. M. Rawn, M. ASCE, Chairman. This 515-page report recommends construction of a primary treatment plant on Point Loma to serve the entire San Diego Bay Area, with discharge of effluent to the Pacific Ocean, 7,500 ft. off shore in 125 ft. of water. Initially the plant would serve more

than 1,000,000 persons and ultimately more than 2,500,000. Recommendations for the North-Coastal area and the Mountain-Desert area are also included. The survey includes studies of climate, tides, population trends, and financing. The formation of a number of sanitation districts is recommended. Previously the state of California, through its San Diego Regional Water Pollution Control Board, issued an excellent detailed report[55] on a pollution survey of San Diego Bay.

Missouri River Drainage Basin

The USPHS has adopted a comprehensive program of pollution control for the Missouri River Drainage Basin.[18] The Missouri Basin is the first major basin for which this has been done. Prior thereto the USPHS issued reports on cooperative Local-Federal pollution studies on which to base recommendations for control for all of the 15 major basins in this country. Under the Federal Water Pollution Control Act, the USPHS is required to prepare or adopt comprehensive pollution abatement programs in cooperation with other Federal Agencies, State and Interstate water pollution control agencies, municipalities, and industries. The report, developed cooperatively by the USPHS Missouri Drainage Basin office and the Water Pollution Control Agency of each of the ten Missouri Basin states, lists specific project requirements at 893 locations where communities and industries are now discharging untreated or inadequately treated wastes. The total cost of the abatement works is estimated at $186 million.

Pollution Abatement Program for the Kansas River Basin

A comprehensive plan for the abatement of pollution in the Kansas River Basin is described by D. F. Metzler, M. ASCE[15], with emphasis on the development and administration of the program. Twenty-three new sewage treatment plants have been built in the first 3-1/2 years of the program and 27 other cities lacking sewage treatment are in various stages of planning.

Stream Sanitation in the Tennessee Valley

Pollution in the Tennessee River system increased at least 35% between 1941-51, according to a report[16] issued by the Tennessee Valley Authority. The report cites 10 large sources of pollution which would require an expenditure of nearly $25 million for correction. Of the 10 sources cited, Chattanooga and Knoxville constitute the largest problems, with both cities now discharging untreated sewage into the river. Four pulp and paper mills, three rayon plants, and one chemical plant are the other eight major pollution sources.

Maumee River Basin

The Ohio Department of Health and the Indiana Stream Pollution Control Board made a detailed pollution survey[17] of the Maumee River Basin in 1950-51. Considerable treatment of sewage and industrial waste is urged, especially in the areas around Toledo and Fort Wayne. Many toxic wastes were found, against which the following guides were set as a tentative basis for protection:

		P.P.M. In Receiving Waters
Cyanide (as CN)	Not Over	0.15
Lead (as Pb)	" "	0.35
Copper (as Cu)	" "	0.40
Chromium (hexavalent)(as Cr)	" "	2.0
Cadmium (as Cd)	" "	0.4
Zinc (as Zn)	" "	1.0
Nickel (as Ni)	" "	5
Nitrate (as N)	" "	10

Concentrations of Fe and Mn are not to exceed 5 ppm. The allowable pH range in the receiving water is 6.3 to 9.0. Fluorides are to be under 1.5 ppm at water-works intakes.

Pennsylvania's River-By-River Clean-Up

Pennsylvania is reclaiming two more polluted rivers, the Juniata River and the Lehigh.[19] These follow the restoration of the Schuylkill. The largest treatment projects on the Juniata will be at Altoona and Lewistown. On the Lehigh, desilting systems to remove silt from coal washings together with construction of sewage treatment plants by a number of cities including Bethlehem, Easton and Lehighton are the principal factors in pollution abatement, along with a number of industrial waste treatment plants. In Pennsylvania at the beginning of 1954, 29 sewage treatment plants were being built and 116 rehabilitated. The three Philadelphia plants and their intercepting sewers will cost approximately $60 million, while another $30 million is being spent on sewage treatment throughout the state.

Savannah, Georgia

The USPHS has issued an interim report[20] dated October 1952 on a survey of the Savannah River between Georgia and South Carolina where radioactive wastes are an existing or potential factor because of the Savannah River Plant of the Atomic Energy Commission. The river basin is predominantly a rural area, with about 20% of the population residing in Augusta and Savannah. Measurements were made of the radioactivity associated with the suspended solids in the river water as well as with aquatic life in the river prior to the initial operation of the AEC Savannah River Plant. One of the main objectives was to determine the natural radioactivity in the river and follow any changes after the plant was placed in operation. The total alpha radioactivity was 4.2 ± 2.0 micromicrocuries. The maximum total beta radioactivity found in any sample was 40.4 ± 15.6 uuc/1. The alpha radioactivity of all samples of fresh water organisms exclusive of fish bone was 4.8 ± 3.9 uuc. or less, and the beta activity was 14.3 ± 5.6 uuc. or less per gram of wet weight sample. The maximum alpha activity of fish flesh was 1.5 ± 0.9 uuc./g. It is planned to reestablish these studies at intervals subsequent to the initial operation of the AEC plant.

Sewage Disposal and Tidal Estuaries

A. N. Diachishin, J. M. ASCE, Seth G. Hess, M. ASCE, and W. T. Ingram, A.M. ASCE, discuss sewage disposal in tidal estuaries[21], largely from the standpoint of New York Harbor and the Hudson River, commenting on errors

in various methods of computation. The influence of the tide on sewage discharged into tidal waters varies widely for individual areas. It is difficult to estimate dilution volumes and detention periods in a given estuary without an individual study of tidal action in the estuary. The various types of tidal action are described (progressive wave, stationary wave or hydraulic flow) and how these are influenced by density currents, wind and weather. The tidal prism theory constituted the first attempt to evaluate the role of tidal action in sewage disposal. According to this theory, the entire volume of water between high tide and low tide—a tidal prism— is available for sewage dilution in each tidal cycle, and in each cycle the prism is renewed with a supply of fresh sea water that mixes completely with the water below the low-tide line. The authors show that the tidal prism theory usually over-evaluates the cleansing action of the tide. Ketchum's modification of the tidal prism theory is an improvement but is still subject to many errors. The use of models and gathering of further field data are urged to arrive at a truer understanding of the effect of tidal action on sewage disposal.

C. P. Lindner, M. ASCE,[22] discusses the somewhat related problem of intrusion of sea water in tidal sections of fresh water streams. Data are given on the tide, current and salinity for four streams in the southern United States, three on the Atlantic seaboard and one on the Gulf of Mexico.

Effect of Cabin Cruiser Waste on a Small Boat Harbor

W. T. Ingram, M. ASCE, and A. Diachishin, J. M. ASCE, present[23],[37] a rather unique survey made in the summer of 1953 to determine the effect of cabin cruiser waste discharge on a sheltered harbor at Eatons Neck in the area under the jurisdiction of the Interstate Sanitation Commission on the north shore of Long Island. Measures to improve the handling and treatment of craft wastes before discharge appear desirable and may be necessary in some harbors.

Bathing Water Quality and Health

Studies to relate the health of swimmers to the bacteriological quality of bathing waters were reported by A. H. Stevenson, A.M. ASCE.[24] Three separate studies made on Lake Michigan at Chicago; the Ohio River at Dayton, Ky., and a near-by swimming pool; and Long Island Sound, were carried out by the USPHS. The results indicated a higher incidence of illness among swimmers than among non-swimmers, regardless of bathing water quality. Ailments of the eye, ear, nose, and throat accounted for more than 50% of all illnesses in this study. Although no consistent relationship between illness and bathing water quality could be demonstrated, a significant increase in illness incidence was observed among swimmers at Chicago on three days when the water had an average coliform content of 2300 per 100 ml. A second instance of positive correlation was observed in the Ohio River study where swimming in water having a median coliform density of 2700 per 100 ml. appeared to cause a significant increase in gastrointestinal illnesses. However, the report stated that "sufficient evidence is available to indicate that some of the strictest bacterial quality requirements for natural bathing water now existent might be relaxed without significant detrimental effect on the health of the bather."

Factors Involved in Disposal of Sewage Effluents to Lakes

C. N. Sawyer[25] discusses the disposal of sewage effluents to lakes in relation to nuisance blooms of algae. Sewage contains all the ingredients needed

to support luxurious growth of algae and an ultimate yield of about 2,000 lbs. per mg can be expected. In southeastern Wisconsin lakes, he found that if the nitrogen and phosphorus content exceeded 0.30 and 0.01 ppm, respectively, at the start of the growing season, nuisance blooms would usually follow. Lakes subjected to fertilization by sewage effluent may require years to recover their former status when the effluent is diverted. Since fertilizing material also enters lakes from ground waters and streams, an evaluation of the amount contributed from these sources is necessary before estimating a safe loading of sewage effluent. In discussing this paper, H. B. Gotaas, M. ASCE, states that it is probable that surface and ground water flow to lakes contributes a major part of the nutrients for algae. Where sewage is an important factor, the sewage nutrients could be removed by growing algae in ponds and removing the algae before emptying the effluent into the lake. The green algae contain about 50% protein, 30% fats, 5% carbohydrates, and 15% ash, and may be of value as stock feed. J. B. Lackey adds that studies on the use of sewage-produced algae as food or food additives for animals may be worthwhile.

Analysis of Stream Capacity for Assimilating Pollution

M. A. Churchill, A.M. ASCE, offers a simplified method for determining the relationship between organic waste loads put into a stream and the resulting dissolved oxygen depletion.[26] The time of water travel is not needed, the necessary samples can be collected routinely by a small staff and no long-term BOD determinations are required. The analysis develops a relationship between the size of the load, the stream flow and the degree of D.O. depletion.

Legislative Developments

Federal Water Pollution Control Act Extended by Congress

The Federal Water Pollution Control Act of 1948 (Public Law 845) was extended to June 30, 1956 by passage of Public Law 579 in 1952.[27] The original Act would have expired June 30, 1953.

Wisconsin Gives Tax Relief for Waste Disposal Facilities

The Wisconsin State Legislature enacted a statute[28] in 1953 permitting income tax relief to industries in the form of an accelerated 5-year amortization of all capital costs for providing treatment plants, lands for lagoons, or any other facilities designed to curtail the pollution of water resources or the air. In addition the law exempts such lands, lagoons, treatment plants, and other pollution control facilities from all forms of property taxation for a like period of five years. A pre-requisite to property tax exemption and accelerated amortization of capital investment is that stipulation in the Act which requires that operating statements covering pollution control operations be filed annually by the beneficiary. Wisconsin is believed to be the first state to enact such tax relief to industry for waste disposal facilities.

Pennsylvania Grants 2% Subsidy for Sewage Works

The Municipality Authorities Act of 1954 in Pennsylvania provides for the creation of Authorities for financing public works through the sale of revenue bonds without a referendum and for providing revenue through sewer rental charges to retire the bonds and pay annual operation and maintenance costs (267). The Commonwealth also passed a law under which it will pay a subsidy to municipalities of 2% of the construction cost of intercepting sewers and

treatment plants built since 1937, and for those built in the future under orders of the Pennsylvania Sanitary Water Board. This is believed to be the first instance of direct state aid in financing sewerage works.

Litigation

Anti-Pollution Order Upheld in Wisconsin

The Wisconsin State Committee on Water Pollution in 1950 ordered the City of Superior to build a sewage disposal plant.[29] The city appealed to the courts contending that the order exceeded the Committee's authority and that compliance with it would require the city to go beyond constitutional debt limits. The city requested that the order be voided. The Wisconsin Supreme Court upheld the lower court's dismissal of this request, which in effect, ordered the city of Superior to build a $2 million sewage disposal plant.

Three-Year Court Battle at Norwich, Conn.

Culmination of a 3-year legal battle has been reached by issuance of an order by the Connecticut Supreme Court that the City of Norwich build a $1.8 million sewage treatment plant[30], thus forcing the City to comply with a State Water Commission edict.

Interstate and Other Joint Compacts

Ohio River Valley Water Sanitation Commission

The Ohio River Valley Water Sanitation Commission issued its Fourth[33] and Fifth[34] Annual Reports for the years 1952 and 1953. Forty-three per cent of the sewered population of 9,319,000 is receiving some form of treatment. An additional 10% are building new facilities and 16% have final plans ready for construction. On the industrial front, the record shows that of 1,247 industries discharging directly into Ohio Valley streams, 817 now operate control facilities, 31 are constructing facilities and 117 are completing plans for installation of wastes treatment plants. The report summarizes activities of eight states in water pollution control in the Ohio River Valley. Action by 113 municipalities is also summarized as well as the status of industrial waste control facilities. The treatment standards of the Commission are outlined. The report concludes with a list of the Commission's publications, which will interest those concerned with water pollution control.

The Commission has published[35] a guide describing recommended step-by-step engineering and financial procedures for municipal officials and others interested in clean waters. This is a type of guide which should be available in other states and locations.

E. J. Cleary, M. ASCE, describes the organization and operation of the Commission.[41]

Interstate Sanitation Commission (New York, New Jersey and Connecticut)

The Interstate Sanitation Commission issued its annual reports for the years 1952[36] and 1953.[37] In this interstate area in 1952, treatment plants were completed and placed in operation at Hunts Point, Owls Head and Rockaway, New York City; Port Washington, N. Y.; Linden-Roselle, N. J.; and Fairfield, Conn. These plants are capable of treating over 314 mgd. During 1953, nine additional treatment plants were completed and 10 plants went into operation. These plants provide a treatment capacity of about 61 mgd and included

Port Richmond (Staten Island, N. Y.); Carteret, N. J.; The Joint Outlet Plant (serving portions of Union City, Weehawken and West New York); Peekskill, N. Y.; Stratford, Conn.; Longbeach (Long Island); the East Shore Plant at New Haven; Norwalk, Conn.; Edgewater, N. J.; and Upper Nyack, N. Y. The total flow receiving treatment in this interstate district during 1953 was 950 mgd, of which 775 mgd was rated as adequate treatment. The pollution control program specified in the tri-state compact utilizes both effluent and stream standards.

New England Interstate Water Pollution Control Commission

The New England Interstate Water Pollution Control Commission issued its Sixth Annual Report for the year ended June 30, 1953[38], summarizing pollution control activities during the year. The Commission represents all of New England except the state of Maine, and includes Connecticut, Massachusetts, New Hampshire, New York, Rhode Island and Vermont. Sewage works completed in the Commission area during 1953 include seven new sewage treatment plants with a total capacity of 20 mgd at a cost of $9.5 million.

Minnesota-Wisconsin Interstate Compact

Minnesota and Wisconsin signed a compact[39] for pollution control of the Mississippi River and other boundary streams, agreeing to exchange information and enforce uniform standards on these boundary streams.

Metropolitan St. Louis Sewer District

Formation of a Metropolitan St. Louis Sewer District was approved by the voters of the City of St. Louis and St. Louis County in February 1954, to be effective on July 1, 1954. The District is empowered to construct and operate sewers and sewage treatment plants, and levy taxes to finance them. The City of St. Louis now discharges untreated sewage to the Mississippi River.

Sanitation District No. 1, Kenton and Campbell Counties, Ky.

The sewage treatment plant for Sanitation District No. 1 of Kenton and Campbell Counties, Ky., is nearing completion.[40] The plant and interceptors will cost approximately $7.5 million and will serve Newport (Population 31,000), Covington (Pop. 65,000), and 14 other unincorporated cities. The plant is designed for chemical precipitation, intermediate treatment, and includes sludge incineration.

Development of Sanitary Districts

The interest in metropolitan projects has been stimulated in Illinois by a committee of 17 members appointed by the Governor, with A. A. Olis as Chairman, to consider the metropolitan needs of Chicago and surrounding territory in five counties in respect to water supply, sewerage and sewage disposal.

Development of sanitary districts for water, sewage, drainage, and refuse control is discussed by M. S. Hilbert[42], principally from experience in the Detroit area.

Sewage Treatment Projects

The USPHS reports that a total of 515 communities in the United States awarded contracts for sewage treatment plant construction work in 1952 at a

cost of $137 million.[43] Of these contracts, 314 were for new plants costing $78,414,556 and 201 were for additions, enlargements or replacements of existing plants, costing $58,789,133. The 1952 total of $137 million is less than that for any year since 1948, and falls far short of the annual rate of from $450 million to $500 million estimated to be required over a ten-year period to bring the pollution caused by municipal wastes under reasonable control.

Contracts were awarded during 1953 for 615 sewage treatment projects at a cost of $191 million[44], of which 329 projects were for new plants costing $96 million, and 286 were for additions, enlargements or replacements of existing plants at a cost of $95 million. The total dollar volume for 1953 was about 39% higher than for 1952.

Dollar volume of sewerage contracts has averaged increases of about 30% a year since 1945.[45] The 8-year period from 1945 through 1952 saw an increase of 10% in the number of people served by sanitary sewers and increases of 22% in the number of people served and 30% in the number of places served by sewage treatment plants. Over the same period about 50% more communities began effluent chlorination, trickling filter installations increased 26% and activated sludge plants, 42%.

The USPHS recently estimated that sewage and industrial waste treatment construction is currently proceeding at a $600 million annual rate but a $1.8 billion rate is necessary to eliminate the backlog in five years and also provide for the current population growth.[46]

The present status of some of the larger projects is reviewed below:

Tacoma, Washington

The new Tacoma plant[47], completed in 1952 to reduce pollution in Puget Sound, provides primary treatment for 100,000 people (2/3 of the Tacoma population). The effluent is chlorinated.

Portland, Oregon

Portland's $17 million sewerage system and primary treatment plant will be completed late this year. The treatment plant went into full operation in the Spring of 1953 and by Mid-summer of 1954 was treating about 75% of the total sewage from the city, with the full flow expected by the end of October. As stated in the last report of this Committee[126], the plant is equipped with bar screens and grinders, grit chambers, rectangular settling tanks and sludge digesters. The digested sludge is returned to the plant effluent for discharge to the Columbia River which is always saturated with oxygen and carries a large volume of water at a high velocity. The plant is intended to eliminate local nuisance conditions in the Willamette River which flows through the city before emptying into the Columbia about three miles away. The initial stages of plant operation have been described by J. W. Cunningham, M. ASCE.[49] In a subsequent report to this Committee, Mr. Cunningham states that very satisfactory operation has been experienced with some of the unusual features at this plant including the use of air-operated ejectors for sludge handling, the preheating and seeding of sludge prior to introduction into the digesters, and the heating of the digesters by injected steam. The raw sludge has averaged over 6% solids and the automatic ejectors have handled it satisfactorily. By preheating and seeding the raw sludge, rapid digestion with high gas production is obtained. The nozzles for injecting live steam into the digester are nothing more than pipe reducers. Pumps are used to recirculate the sludge past the steam injector nozzles. Based upon an 8-month average from November 1953

through June 1954, the plant has treated a daily flow of 45.5 mgd and removed 35.5% of the BOD and 61.5% of the suspended solids from a weak sewage.

San Francisco, California

Although $12.6 million in sewerage construction still remains to be done [50], San Francisco placed its new North Point and Southeast sewage treatment plants in operation in 1952. B. Benas, M. ASCE[51], describes all three sanitary district plants and the initial operation of the two new plants. Further operating details are given in the Annual Report for the Fiscal Year ending June 30, 1953.[181]

East Bay Cities, California

The sewage disposal project for six cities spread along the east shore of San Francisco Bay is described by R. C. Kennedy, M. ASCE.[52] A new primary treatment plant is now in operation with discharge of digested sludge into the outfall sewer at times of favorable tidal flows. The outfall extends more than one mile into the Bay. Pre-chlorination is provided.

San Jose, California

Plans and specifications for a $3 million primary treatment plant were approved by the City Council of San Jose, California[53], the last sizeable community still dumping raw sewage into San Francisco Bay. Originally an Engineering Board had recommended a secondary treatment plant with five oxidation ponds on the marsh lands but the city lost a suit to condemn 2,500 acres for the oxidation ponds.[54]

Sacramento, California

Construction work started late in 1952 on a $5.5 million, 54 mgd sewage treatment plant for the Sacramento Metropolitan area.[56] Completion is expected in 1954. The project consists of a primary sedimentation plant with chlorination of effluent, and sludge digestion, elutriation and filtration. Raw sewage from the city has been discharged into the Sacramento River.[57]

Rochester, Minnesota

A new $2 million sewage treatment plant went into operation in Rochester, Minnesota in January 1953.[58], [59] High-rate trickling filters are preceded by rotary fine screens in lieu of the usual preliminary settling tanks. This procedure was chosen because of the presence of a considerable amount of milk waste in the sewage. The much shorter retention period through the screens as compared to the conventional settling tanks lessened the possibility of the sewage becoming septic. A bar screen and grit removal unit precede the screen. Final settling tanks and chlorination of the effluent complete the treatment along with sludge digestion and vacuum filtration.

Chicago, Illinois

Langdon Pearse, M. ASCE, reports that The Sanitary District of Chicago through 1952 had spent on its sewage works construction program a total of $307,688,287, of which $154,764,068 was for intercepting sewers, $135,477,461 for sewage treatment works, and the balance for pumping stations and miscellaneous items. The District's annual operating budget for 1953 was $13,158,298. From the sale of heat-dried activated sludge in 1953 the sum of

$1,419,308 was realized, an average return of $16.48/ton. In August 1954, Congress passed an Act permitting an additional diversion of water from Lake Michigan into the Illinois Waterway, increasing the present 1500 cfs to an annual average of 2500 cfs, for a trial period of three years. The purpose was to improve the sanitary condition of the Illinois Waterway into which the Chicago effluents are discharged. This was vetoed, however, by the President on September 3, 1954. Further background information is contained in the last report of this Committee.(126)

Cincinnati, Ohio

Cincinnati awarded a contract in 1954 for the construction of the second of four projected treatment plants, the 120 mgd Mill Creek plant.(60) The first plant, the $6 million, 29 mgd Little Miami Sewage Works, was dedicated in October 1953.(61) The Little Miami plant is a primary treatment works equipped for chemical treatment of the sewage, with sludge disposal by digestion, elutriation, filtration, and incineration.(62), (63)

Pittsburgh, Pa.

The proposed sewerage system and 150 mgd treatment works for the city of Pittsburgh and 63 neighboring communities in Allegheny County is expected to cost $70 million and is slated for completion in 1958.(64) J. F. Laboon, M. ASCE, has described the Pittsburgh project in some detail(65) and further reports that the plans and specifications have been approved by the State Sanitary Water Board and a construction permit issued calling for completion by June, 1958. The plans have been changed to call for 10 sludge concentration tanks instead of 16 and sludge disposal facilities are based on concentration to 18% instead of 20% solids as reported in the last report of this Committee (126). The Allegheny County Sanitary Authority is waiting for authorization from the City of Pittsburgh before proceeding with construction.

Philadelphia, Pa.

The $80 million sewage treatment program for Philadelphia was 66% completed at the end of 1953 in terms of contracts completed or awarded, with $14 million in additional contracts scheduled for award in 1954.(66) Three treatment plants are planned. The $13 million, 125 mgd Northeast plant(67) was placed in operation in 1951 and its early operating experiences are described by R. A. Hoot.(68) The 136 mgd Southwest plant is scheduled for completion late in 1954. The 140 mgd Southeast plant is also under construction.

Bethlehem, Pa.

A new $5 million, 12.5 mgd high-rate trickling filter treatment plant serving 100,000 persons at Bethlehem, Pa., is described by R. L. Fox, M. ASCE (69). Sludge disposal is by digestion, filtration, and drying or incineration.

Louisville, Ky.

A new 90 mgd, $6 million treatment plant was approved by the voters in November 1953, for construction at Louisville, Ky.(40)

Boston, Mass.

The Boston Metropolitan District Commission has awarded contracts for a $12 million tunnel which will be built under Boston Harbor to convey sewage

from South Boston to a proposed 800 mgd Deer Island Treatment Plant. The tunnel will replace the present conduit which discharges sewage without treatment at Moon Island. The seven-mile-long tunnel will have a diameter of 11.5 feet and its capacity will be 450 mgd. Another four-mile-long 350 mgd tunnel, the $6 million north metropolitan, is nearing completion to Deer Island as part of a $75 million Boston sewage disposal program.[127]

Blackstone Valley, Bucklin Point Plant, Rhode Island

The Bucklin Point sewage treatment plant of the Blackstone Valley Sewer District Commission of Rhode Island went into continuous operation in August 1953. The design of this plant is described by J. H. Bethel, Jr., M. ASCE.[70] The $3 million, 23.5 mgd primary treatment plant includes chlorination and sludge digestion, elutriation, filtration, and drying or incineration. E. B. Cobb, M. ASCE, reports that the Blackstone Valley interceptor sewer system is now being extended further into the Valley and also into East Providence.

New York City

New York's $317 million treatment program is described by R. H. Gould, M. ASCE, and others[71], with design details on the Owls Head activated sludge plant, the Hunts Point step-aeration activated sludge plant, the Rockaway high-rate activated sludge plant, and the Port Richmond primary treatment plant which will be expanded later to high-rate activated sludge. The sewage disposal problems in the world's largest city are discussed by Gould [72]. The 1953 Annual Report, Department of Public Works in New York City, lists eleven modern sewage treatment plants in operation with a design capacity of 761 mgd, treating 667 mgd, and four old plants built prior to 1935. Seven new plants and two expansions are in design or about to be constructed, with a total capacity of 666 mgd. The total sewage treated in 1953 was 688 mgd. Total operation and maintenance cost was $4.9 million ($19.50 per mg.). The total construction cost of the New York City program is estimated at $336 million and the cost of plants in operation to date is $132 million.

Middlesex County Sewerage Authority, N. J.

The abatement of pollution in the Raritan River downstream from Boundbrook, N. J. is being undertaken by the Middlesex County Sewerage Authority [73] which has signed contracts with 13 municipal and 7 industrial contributors. E.B. Cobb, M. ASCE, reports that engineering design started in March 1954 and is scheduled for completion in March 1955. The project consists of approximately 23 miles of main sewers and a 52 mgd primary treatment plant, with chemical treatment and chlorination. Sludge disposal is tentative at this time but will probably consist of either concentration and barging to sea or filtration and incineration.

Wilmington-New Castle County, Delaware

The $16 million Wilmington-New Castle County Joint Sewage Disposal system is scheduled for completion in October 1954, and Delaware's most thickly populated area will cease discharging its sewage into the Delaware River.[74] This will fulfill one of the principal aims of the Interstate Commission for the Delaware River Basin (Incodel) and the Delaware State Water Pollution Commission. The $3 million, 40 mgd primary treatment plant will include sludge disposal by elutriation and lagooning in a remote marsh area. The elutriation is intended to wash out chromium and other toxic wastes so that the sludge can digest in the lagoon.

Miami, Florida

Construction started in July 1953 on the $22 million Miami sewage treatment project which is scheduled for completion in July 1956, according to E. B. Cobb, M. ASCE. J. S. Bethel, Jr., M. ASCE, describes the proposed $10.9 million, 47 mgd treatment plant[75] serving 350,000 population by a modified activated sludge process. The effluent will be discharged one mile off shore into the Atlantic Ocean. The plant includes aerated grit chambers, aeration tanks (2.75 hr. detention), final settling tanks (2.5 hr. detention), with sludge disposal by concentration, digestion, elutriation, filtration, and incineration. No preliminary settling tanks are provided, so the final tanks will be provided with scum removal equipment. The air supply will be 0.96 cu. ft. per gal. of raw sewage. Sludge disposal studies indicated that fertilizer production would not be economical at this time.

Aukland, New Zealand

A $25 million sewage works program including large oxidation ponds was adopted by the Metropolitan Drainage Board of Aukland, New Zealand, following a report by a survey panel including three American engineers[76] which recommends the largest oxidation pond installation ever attempted, with four ponds having a total effective area of 1100 acres. The plant will also include bar screens, pre-aeration and grit removal tanks, sedimentation tanks, auxiliary trickling filters, with sludge disposal by digestion and lagooning in a natural volcanic cone with a 50-year capacity. The 1951 population of the area to be served was 296,000. The sedimentation-trickling filter-oxidation pond plant was finally chosen in preference to a previously considered activated sludge system because the construction cost is estimated at only 70% and annual costs at 60% of the activated sludge plan.

Enlargements of Existing Plants

Los Angeles, California

The $44.7 million, 245 mgd modified activated sludge Hyperion Plant in Los Angeles, which went into full operation in 1951, is already nearing design capacity due to rapid population growth. Expansion of the plant to handle an additional 100 mgd was recommended by the City Engineer.[77] A difference of opinion has arisen, however, as to the best method of providing increased sewage disposal facilities for the city.[78] In July 1953, City Engineer Lloyd Aldrich, M. ASCE, recommended a $39.5 million five-year program including additional trunk sewers and expansion of the Hyperion Plant. In January 1954, A. M. Rawn, M. ASCE, of the Los Angeles County Sanitation District, submitted a report[79] made at the request of the City of Los Angeles on the possible disposal of a portion of the city's sewage through the facilities of the County Sanitation Districts. The County Sanitation Districts now operate a 150 mgd disposal system which includes primary treatment with chlorination and deep water discharge of the effluent. Sludge disposal is by digestion and drying on open-air beds. Estimated costs and relative adequacy of the two radically different proposals for relieving the city's sewage disposal problem are now being studied by a Citizen's Committee appointed by the Mayor which is expected to hold hearings and recommend action. Meanwhile, the city has appropriated $668,000 for additional work at the Hyperion Plant including additional air-blower capacity.

Operation of the Hyperion Plant is described in the Annual Reports of the

Bureau of Sanitation, Department of Public Works, for the Fiscal Year 1951-1952 and 1952-1953.[80], (81) For the fiscal year 1952-53, the plant served an estimated population of 2.5 million with an average flow of 230 mgd. Overall removals included 76.7% of the suspended solids and 73.5% of the BOD. Air-consumption averaged 0.76 cu. ft. per gal. compared with the design expectation of 0.51 cu. ft. per gal. Even so, aeration capacity was sufficient to permit high-rate activated sludge treatment in half the plant only, the other half being operated by plain aeration with no return of solids. Additional air blower capacity will be installed. Sludge digestion has been very successful and loading rates almost double those anticipated in the design have been found feasible. Sludge drying produced a total of 22,626 tons of fertilizer, or an average of 1,885 tons per month. The total operating cost was $1,617,870, reduced by $89,790 through fertilizer sales. The net cost per mg treated was $18.19, or $0.61 per cap. The elutriated digested sludge required an average of 4.8% $FeCl_3$ for conditioning prior to vacuum filtration.

Phoenix, Arizona

The original 12 mgd activated sludge plant built in 1932 at Phoenix has been expanded to 30 mgd capacity.[82] The effluent is chlorinated and the digested sludge is air-dried on earth beds without under-drains as the evaporation is about 45 in. per year. The sewage temperature rises to a range between 80 and 87°F. and tends to develop hydrogen sulfide which is controlled by the application of home-made ferrous chloride to the trunk sewers at strategic points.

Milwaukee, Wisconsin

R. D. Leary reports additions and improvements at the Milwaukee activated sludge plant. To augment present rotary sludge drying equipment, the Milwaukee Sewerage Commission completed the installation of two turbo-dryers which consist of 58 circular drying trays with the wet cake entering the top and traveling downward over each tray, with the hot drying air circulating over each tray by fan action. These two dryers have an evaporating capacity of 24,000 lb. of water per hr. each. They have been operating at about 80% capacity since installation in 1950. The Commission is completing a replacement program of the original 11' 6" x 14' vacuum filters with new units 13' x 16', 17 of the units having been replaced to date out of a total of 24 filters in service. The new filters have 30% greater capacity. The ferric chloride sludge conditioning equipment has been remodeled. The capacity of some of the sewage and sludge pumps has been increased by the installation of larger drive motors.

Chicago, Illinois

In December 1953, the Chicago Southwest Sewage Treatment Plant (the largest in the world) put into operation 66 new vacuum sludge filters, the last major step in its treatment improvements.[83] With the 32 original filters, the plant will have a capacity of 400 to 500 tons of dried sludge daily for sale as a commercial fertilizer base. The new filters will eliminate the need for the adjacent sludge lagoons on the Des Plaines River.

Detroit, Michigan

F. H. Burley, A.M. ASCE, reports that the Detroit primary treatment plant will be expanded as follows:

2 additional main sewage pumps, 230 cfs each, in space provided in the original pumping station construction;
2 additional sets of bar screens and grit collectors in channels provided in the original construction;
2 additional sedimentation tanks to be constructed west of the eight existing tanks, with the same length and width as the present tanks, but less depth (approximately 10 ft. compared with 14 ft. in the existing tanks which are 117 ft. wide and 272 ft. long).
4 additional vacuum filters in space provided in the original filter building construction. This will bring the total installation to twelve 500 sq. ft. filters and will utilize all of the available space in the existing building.

The added facilities are made necessary principally by the construction of a new interceptor sewer from the northwest area of Detroit, scheduled for completion in January 1955 and expected to impose an additional load on the treatment plant of 65 mgd. Completion of the various phases of this work is scheduled for 1955 and 1956. It is expected that the shallower sedimentation tanks will have little effect on the removal efficiency.

Grand Rapids, Michigan

Grand Rapids is preparing plans for enlarging its primary treatment plant by the construction of $5 million secondary treatment facilities, using an activated sludge process.[84]

Cleveland, Ohio

Cleveland's Southerly sewage plant is abandoning its original trickling filters and installing activated sludge for secondary treatment. The trickling filters have clogged beyond economical rehabilitation.[85] An estimated $9.1 million will be spent in increasing the capacity of the Southerly plant from 36 mgd to 68 mgd and providing activated sludge treatment.[86] F. S. Palocsay, M. ASCE, describes the design features of the external heat exchangers for preheating sludge at this plant prior to digestion.[87] New sludge digestion and elutriation tanks were completed in 1952 at a cost of $2.0 million.[88]

Toledo, Ohio

Proposed sewage works improvements at the Toledo primary treatment plant have been described by T. B. Henry, M. ASCE.[89] Secondary treatment will be provided. Construction is currently being delayed awaiting financial authorization which will probably require doubling the sewer rental rate of 25% of the water bill.

Indianapolis, Ind.

Indianapolis has enlarged its sewage treatment facilities by the construction of $1.6 million primary sedimentation units having a capacity of 120 mgd compared with 80 mgd in the old plant. Temporarily, sludge disposal will be in lagoons pending the construction of sludge incinerator units to be completed in 1955.[90]

Buffalo, New York

In January 1953, Buffalo inaugurated a two-stage program for expansion of its Bird Island sewage treatment plant. The first stage will increase

digestion capacity by 125% and includes four new digestion tanks, two elutriation tanks and a sludge control building at an estimated cost of $1.45 million. Construction was about 75% completed as of July 1, 1954. With the new digesters, G. F. Fynn reports that the installed capacity is 2.9 cu. ft. per cap. for the present population of 576,000. External heat exchangers will be used and provision for high-rate re-circulation is being made. Plans are being prepared for the second stage of the program which will increase sedimentation capacity approximately 100% at this primary treatment plant.(91)

Schenectady, New York

E. S. Ordway, M. ASCE, describes the rehabilitation of the 38-year old Schenectady Imhoff tank-trickling filter plant.(92) The original capacity of 12 mgd for 90,000 population was increased to 20 mgd for an expected 1970 population of 125,000. The Imhoff tanks were converted to mechanically cleaned settling tanks. The trickling filters in the old plant could accommodate only about 55% of the flow. This insufficient secondary treatment has now been replaced by adequate primary treatment with chlorination of the effluent to meet existing State stream classification standards. Sludge disposal is by digestion, vacuum filtration and heat-drying, or air-drying of the digested sludge on the old sand beds. The dried sludge is bagged and sold under the name of "Orgro" (93).

Washington, D. C.

R. E. Fuhrman, M. ASCE, reports that a sewage chlorination station and a sludge disposal plant are now under construction at the District of Columbia sewage treatment plant. The sludge disposal facilities provide heat-drying or incineration and are scheduled for completion this year. Secondary treatment facilities consisting of high-rate activated sludge has been authorized at an estimated cost of $10.3 million, with completion presently scheduled for one-half in 1956 and one-half in 1959. Previously, four additional settling tanks and four additional sludge digestion tanks were installed as mentioned in the last report of this Committee.(126)

Charlotte, North Carolina

A $7 million program of replacements and improvements has been under way since 1947 at the Irwin Creek and Sugar Creek sewage treatment plants at Charlotte, N. C. (94) The city, with a present population of 145,000, is situated on two drainage areas and is served by two treatment plants. Sludge concentration tanks now under construction at the Irwin Creek plant are designed to operate on the principle of the Laboon process, demonstrated on a pilot plant scale by J. F. Laboon, Chairman of the Allegheny County Sanitary Authority, Pittsburgh, Pa. Charlotte will be the first city to apply the Laboon process of concentrating sludge by flotation under controlled temperature. The concentration tanks will receive raw and excess activated sludge from the primary clarifiers. The sludge will be heated to 95°F. as it passes through an external-type heater before entering the tanks. Four 6,700 cu. ft. tanks are provided to operate on a fill-and-draw basis, the sludge being held in the tank for two or three days. Operating personnel believe that a concentration of 12% solids will be as dense as practicable before transferring the concentrated sludge to the digestion tanks by plunger-type pumps.

Winnipeg, Canada

The Greater Winnipeg Sanitary District has awarded contracts for construction of a third clarifier, four additional digesters, and other miscellaneous improvements. The completion of this expansion is scheduled for late this year and will increase the capacity of the treatment plant from 25 mgd to more than 42 mgd (U.S. gals.). Present digester capacity will be tripled. The method of sludge disposal has not been finally settled but will probably be a combination of lagooning and vacuum filtration.[95] N. S. Bubbis describes the problems of the Sanitary District[96] which serves a population of about 300,000 in an 80 sq. mi. area. Packing-house wastes overloaded the original digesters designed for one cu. ft. per cap. The cost of sludge elutriation, conditioning with ferric chloride, vacuum filtration, and removal of sludge cake had risen from $14 per ton of dry solids in 1944 to $23 per ton in 1952, so the use of sludge lagoons is now being explored.

Toronto, Canada

The main Toronto sewage treatment plant at Ashbridges Bay began operation in 1951 with primary treatment and chlorination. Sludge disposal is by digestion, elutriation, filtration, and incineration or drying. L. B. Allan, Toronto Commissioner of Works, reports that construction of activated sludge secondary treatment facilities at this plant is scheduled to commence in 1955. N. G. McDonald, M. ASCE, reports experimental use of the Perth process of gas re-circulation in one of the digestion tanks with encouraging results. The plant will be expanded to serve a population of one million at an estimated cost of $26 million.

Some Design Developments

Sewer Design

The determination of design capacity of sewers is discussed by W. E. Stanley, M. ASCE, and W. J. Kaufman, J. M. ASCE.[97] Capacity design for sanitary sewers and for storm sewers is presented, including the hydrograph method of storm sewer design. An appendix describes design practice in over 20 cities. G. O. Consoer, M. ASCE, has presented a check list of special features in interceptor sewer design[98], with design criteria on size, control devices, grade and siphons. L. M. Laushey, A. M. ASCE, reports on special studies made for the design of deep drop shafts for the proposed Allegheny County Sewerage System at Pittsburgh.[99] A spiral flow with vortex down the center of the shaft was found best in model studies.

The problem of cooling waters from air condition systems encroaching upon the capacity of sanitary sewers has been faced by Los Angeles. F. R. Bowerman, J. M. ASCE, reports that the city and county will not accept uncontaminated one-pass cooling water in the sewer. Blow-down from cooling towers or evaporative condensers may be discharged to the city sewers up to 2% of the circulation rate, while the county limits such discharge to one-half of the evaporation rate or one-third of the make-up. The trend is toward air-cooling in lieu of water-cooling for air conditioning units up to 5 H.P.

Aerated Grit Chambers

Some design details have been published on aerated grit chambers for the new Pittsburgh[65] and Miami[75] sewage treatment plants, patterned after

the first large installation in Columbus, Ohio. For Pittsburgh, the grit chambers are designed for a detention period of five minutes and air application of 5 cfm per ft. of length. Hoppers for grit storage and drainage are provided. At Miami, spiral flow through the grit chambers will be maintained by the use of removable air-diffusers. Variable-speed blowers will furnish a maximum of 5.25 cfm per ft. Grit separated from the sewage is deposited in a trench beneath the diffuser tubes and is removed, elevated and discharged to pneumatic grit ejectors by bucket elevators.

Sedimentation

A few studies on sedimentation have been reported. T. R. Camp, M. ASCE, (100), presents an excellent study of sedimentation basin design in which he points out the advantages of long, narrow, shallow tanks. The effects of tank depths on sedimentation have been brought out in studies at Purdue University (101) by D. E. Bloodgood, M. ASCE, and W. E. Howland, A.M. ASCE. Data collected on an experimental tank substantiated Hazen's theory that sediment removal is dependent on surface area and independent of tank depth. Decreasing the depth by one-half resulted in practically no reduction in sediment removal when compared on the basis of identical flow. Decreasing the depth by one-half resulted in increased removal of solids for identical detention times.

Sedimentation vs. flotation in treating wastes is discussed by A. A. Kalinske, M. ASCE(102), who concluded that the choice will depend on the settling characteristics of the solids; flotation permits use of a smaller basin than does gravity settling but will not produce as highly polished an effluent and the operating costs will be greater. A thicker sludge can be obtained from the flotation unit, however. Vacuum flotation at Santa Maria is discussed by T. J. Mays.(103) A 26-ft. diameter Vacuator is used at this plant to relieve badly over-loaded primary clarifiers. A vacuum of 9 in. of mercury is maintained in the Vacuator, which will remove 35 to 55% of the suspended solids and 35 to 40% of the 5-day BOD.(104) Detention times range from 10 to 25 minutes. More than 40 of these units are now in service.

F. R. Bowerman, J. M. ASCE, reports the installation of a series of inclined baffles in a new primary sedimentation tank for the Los Angeles County Sanitation Districts, based on studies by J. E. McKee, M. ASCE, and associates, (to be published soon in the ASCE Separates) on the effect of scour on settled sludge in sedimentation tanks. The sedimentation tank is 18 ft. wide, 10 ft. deep and 300 ft. long. In the first one-half of the tank, the baffles will extend from the top of the scrapers, or flights, upward 3-1/2 ft., leaving a water depth of about 4-1/2 ft. over the top of the baffles. The baffles are inclined in the direction of flow (at a slope of 3 vertical to 1 horizontal) and spaced at 4-ft. intervals. In the last one-half of the tank, excepting the last 25 ft., the baffles will extend 1 ft. upwards from the flights and are spaced 2 ft. apart. It is anticipated that the baffles will prevent re-suspension of settled sewage solids and provide a denser and more uniform sludge.

Air Diffusers

Miles Lamb discusses the design and maintenance of porous tube diffusers to get top aeration efficiency.(105) Important factors include the mounting and spacing of the tubes, balancing the air supply with the oxygen demand, quality of air, and cleaning of tubes. Operation of Impingement-type aerators at Kirkwood, Mo., is described by J. Kruegel.(106) Both types of aerators are in use at the Los Angeles Hyperion plant but no data on their relative efficiencies are

available. J. F. Laboon, M. ASCE, reports that alternate bids on both types of aerators may be taken for the new Pittsburgh plant. A. T. Ippen, M. ASCE, and C. E Carver, Jr., J.M. ASCE, present a study of the basic factors of oxygen transfer in aeration systems.[165] Some conclusions reached include: Increasing the number of diffusers and decreasing the size of the bubbles favors increased absorption from a given flow of air; total air absorption increases almost linearly with depth.

Digesters

J. J. Closner discusses prestressed concrete for sludge digestion tank construction.[107] Savings up to 46% in concrete and 72% in steel are claimed. The prestressed method was used in the construction of the approximately 3 million gallon digestion tanks at Los Angeles, New York City and Philadelphia, as well as in numerous smaller installations.

Sewage Lagoons, Oxidation Ponds and Land Disposal

A negative view on the use of sewage lagoons is taken by R. J. Ellison, A.M. ASCE, and R. L. Smith.[108] W. Van Heuvelen cites successful experiences with sewage lagoons in North Dakota and elsewhere.[109] W. J. Wenzel, M. ASCE, discusses the use of sewage lagoons for western plains areas[110], finding them to be the lowest cost satisfactory treatment method at suitable locations. He recommends a lagoon area of 10 acres per 1,000 population, located at least one-half mile out of town, and with water depths 3 to 5 ft. W. Van Heuvelen and J. H. Svore give further details on the design, construction and operation of sewage lagoons in North Dakota.[111]

Ralph Stone, A.M. ASCE, presents a detailed discussion of land disposal of sewage and industrial wastes.[112] A. E. Greenberg and J. F. Thomas discuss sewage effluent reclamation for industrial and agricultural use[113], describing a study at the University of California on the spreading of sewage effluents on land. V. M. Ehlers, M. ASCE, and D. Whittington discuss experience with sewage oxidation ponds in Texas[114], in which there are approximately 135 oxidation ponds in operation. Choice of this method of sewage treatment is limited primarily by two factors, i.e., climatic conditions and site available. The optimum depth and loading should be 2.5 to 3 ft. and 50 lb. of 5-day BOD per acre per day, respectively. In Texas the per capita cost for treatment plants consisting of settling tanks and oxidation ponds ranges from $8 to $12, compared with $18 to $25 for conventional mechanized sewage treatment plants. The design and application of oxidation ponds in Texas is also discussed by D. F. Smallhorst.[116] I. Nusbaum, A.M. ASCE, comments on the satisfactory use of oxidation ponds in California and elsewhere.[109] W. L. Wang and S. G. Dunlop report on an investigation of animal parasites in sewage and irrigation water at Denver, Colo.[115] Some Ascaris ova and other ova of the hook-worm group were found in the treated effluent of the sewage plant and in the receiving river as used for irrigation. No definite conclusions were drawn as to the public health significance of these findings as little is known of the minimum infecting doses of these organisms.

Electric Power Systems for Sewage Plants

M. C. Boggis and N. L. Hadley discuss electric power system practices for sewage plants[117], including types of power supply and distribution systems, voltage selection, grounding and electrical equipment.

Centrifugal Pump Design for Large Volumes of Sewage and Storm Water

H. J. Meeker discusses developments in centrifugal pump design including special considerations in sewage and storm water pumping.[118]

Sewage Disposal Systems in Rural and Fringe Areas

M. H. Klegerman, A.M. ASCE, discusses sewerage planning for metropolitan fringe areas.[119] The APHA Committee on Rural Sanitation presents a progress report on rural sewage disposal systems[120], including septic tanks and absorption fields. Sewage treatment for resort areas is discussed by O. Borden, M. ASCE, and E. B. Rodie[121], based on experience in New York state. C. C. Spencer discusses sewers for fringe areas and believes combined sewers are justified in many cases.[180]

Micro-straining of Sewage Effluent

S. C. Evans and F. W. Roberts describe the filtration of sewage plant effluents through a fine mesh rotating screen at Luton, England.[122] In this country, C. E. Keefer, M. ASCE, describes the use of a small, experimental unit at Baltimore on trickling filter effluent.[123] The average removal of suspended solids from the trickling filter effluent by the micro-strainer was approximately 55% and was comparable with the results accomplished by humus tanks. The fine screen contains 75,000 apertures per sq. in. and is cleaned by washing with water sprays.

Plant Operation

Laboratory Control

F. W. Gilcreas presents an excellent series of 14 articles on better plant operation with laboratory control.[124]

Safety

L. W. Van Kleeck, M. ASCE, presents a valuable series of 7 articles on safety in sewage works maintenance and operation.[125]

Annual Reports

A considerable number of cities publish annual reports covering operation and maintenance of sewage treatment plants, revealing much valuable information on the way these plants actually operate after construction, and the modifications necessary or desirable. Space will not permit review of these reports by this committee. Included among the many cities issuing such reports are the following: San Francisco; Los Angeles; San Diego; Minneapolis-St. Paul; Kenosha, Wis.; Racine, Wis.; Green Bay, Wis.; Aurora, Ill.; Gary, Ind.; Richmond, Ind.; Marion, Ind.; Detroit; Toledo; Cleveland; Buffalo; Washington, D. C.; New York City; Worcester, Mass.; Cranston, R. I.; Waterbury, Conn.; Hartford, Conn.; New Britain, Conn.; Winnipeg, Canada.

Langdon Pearse, M. ASCE, reports on the city of Chicago which has the world's largest installations providing complete treatment to the sewage and wastes from the city. In 1953, The Sanitary District of Chicago operated its three main sewage treatment works handling a total of over 1100 mgd with activated sludge treatment.

1953 Operating Data
The Sanitary District of Chicago

Works	Sewage Treated m.g.d.	BOD - 1,000 lb. Daily Raw	Effluent	Area Tributary Sq. Miles
Calumet	94.9	90.7	9.3	112
North Side	200.5	156.9	10.8	122
West-Southwest	808.4	1,146.0	106.7	257
Total	1,103.8	1,393.6	126.8	491

Effect of Detergents

The effect of detergents on sewage plant operation has continued to receive much attention. R. W. Simpson reviews the literature from 1947 through 1950 on the effect of synthetic detergents on sewage treatment.(128) The commonly used detergents have BOD values lower than soaps and therefore may lower the BOD of raw sewage as they replace soap. Increased use of detergents may make sewage more difficult to treat and may become a source of trouble in water supply treatment when carried into streams by treated sewage. D. R. Bowers presents studies on the lowering of surface tension of sewage due to detergents.(129) A number of laboratory procedures for the determination of synthetic detergents in sewage are presented(130), (131), (132) and (133).

W. R. Gowdy describes the chemical structure of syntehtic detergents and claims that their low concentrations in sewage should not cause frothing or settling problems.(134) L. Flett and L. F. Hoyt describe the composition and behavior of detergent compounds(135), and claim no established proof that frothing and other troubles in sewage treatment have been caused by detergents. W. Rudolfs, M. ASCE, takes exception to these claims and feels that the phosphate content of the detergents may be partly responsible for the difficulties encountered rather than the organic detergents themselves(135) W. R. Gowdy describes a study conducted by the detergent industry at certain activated sludge plants, concluding that frothing problems are caused by too low a concentration of solids in the aeration tanks rather than by detergents.(136) R. E. Fuhrman, M. ASCE, and J. E. Rice believe that changes in sewage characteristics during recent years at the Washington, D. C. plant are partly caused by synthetic detergents.(137) These changes include a reduction of the per capita BOD and a reduction of sedimentation efficiency. D. K. Croft and S. D. Faust report on the concentration of synthetic detergents in the sewage at Hagerstown, Md.(138) The maximum "syndet" concentration of 6 ppm occurred on Monday. The low concentration of 2 ppm occurred on Thursday and Sunday. H. A. Thomas, Jr., studied the effects of detergents on sewage treatment at military installations.(139) He predicts that syndets will cause a reduction in BOD removal in primary treatment, and a reduction in the amount of fuel value of gas from sludge digestion. R. Manganelli and E. S. Crosby report on the effect of detergents on sewage microorganisms.(140) A study in England indicates that synthetic detergents will have a deleterious effect on trickling filters and activated sludge treatment when their concentrations reach 10 to 20 ppm.(141) Among the sewage plants reporting frothing troubles is the new activated sludge plant at Benton Harbor-St. Joseph, Michigan(142) where the froth covered the entire aeration area to a depth of ten feet, and for a distance of 30 feet beyond the tank walls. The sewage contained 8 ppm of synthetic detergents. The mixed liquor solids concentration was varied from

1,000 to 3,500 ppm and the return sludge ratio from 25 to 40% without diminishing the amount of froth. Removal efficiencies have been satisfactory, however. A system of sprays is being installed to control the froth.

Some data are reported on the cost of froth control. At the Los Angeles Hyperion plant, a spray system was installed through 9,600 lineal feet of channel at a cost of $83,000 and $5,000 for a pump, thus approaching $10 per lineal foot for the installation. Approximately 0.4 gpm of spray water (effluent) is required per lineal ft. of tank. Operating costs amount to about $0.19 per m.g.[143] At another plant, using a chemical defoamer solution through sprays, the cost was $0.24 per m.g. for the 6 hours of severe foaming and an average of $0.60 per m.g. on a 24-hr. basis.

Chemical Treatment of Sewage

Very little additional information has appeared on chemical treatment of sewage. T. R. Camp, M. ASCE, presents an interesting discussion on flocculation and flocculation basins, using diffused air aeration and also mechanical flocculators, both with rotating blades and reciprocating blades, citing tests at the Cambridge, Mass. water treatment plant.[144] The fundamental theory of floc formation is presented, together with practical application to the design of flocculation apparatus and basins.

The new Little Miami plant in Cincinnati is designed to provide primary treatment, increased by chemical precipitation when river conditions require it.[63] Alum is the chemical contemplated to be used for this purpose. The chemically treated sewage will flow through an aerated channel supplied with air at the rate of 0.06 cu. ft. per gal. at the average flow of 29 mgd. The sewage then enters four combined flocculation-settling tanks equipped with paddle-type agitation.

Trickling Filters

The effect of loadings and recirculation rates on trickling filter effluents is discussed by W. A. Hardenberg, M. ASCE, and E. B. Rodie.[145] Using the National Research Council efficiency formula, illustrative examples are given for single-stage and two-stage filters. They conclude: (a) For single-stage filters, an increase in the recirculation ratio above 1:1 may not increase filter efficiency enough to justify the necessary increase in settling tank capacity; and (b) for two-stage filters, an increased recirculation ratio will produce a little greater efficiency. If an effluent is required having a BOD of less than 40 ppm, consideration should be given to a two-stage installation. The authors use formulas for calculating the sizes of the filters necessary for producing a given effluent from a given sewage, using either single-stage or two-stage filters with different loadings and recirculation ratios.

R. S. Rankin, M. ASCE, discusses high-rate filters[146] in respect to various combination of stages to obtain any desired degree of treatment between primary and complete. He also evaluates the performance of eight trickling filter plants by three different methods.[147] He concludes that the performance of the plants cited appears dependent primarily upon the rate of recirculation, and that dosing rate, loading of the filter or its depth have no significant effect within the range of values covered by the data. For treatment of average municipal sewage in the smaller plants where one filter is feasible, single-stage filters appear to be most applicable and are capable of producing effluents containing 20 to 25 ppm BOD. For larger plants where multiple filters are necessary or where stronger than average sewage is to be treated, a

two-stage series parallel arrangement of filters should yield a better effluent than single-stage for the same volume of tanks and filters and for the same volume of recirculation. Peter Homack, A.M. ASCE, discusses the Rankin paper by citing experience at the Plainfield, N. J. standard-rate trickling filter at which recirculation was initiated in 1938 to control psychoda flies. This also improved the quality of the effluent. The results tend to substantiate Mr. Rankin's analysis. Bruce Gerber discusses trickling filter design[148] and states that no trickling filter process, its operation, or its efficiency can be completely defined on the basis of one design variable or loading. He proposes to relate trickling filter efficiency and a dimensionless factor involving hydraulic loading, filter depth, and BOD reaction rate.

Activated Sludge

Most of the recent literature on activated sludge is concerned with the so-called high-rate or short-period modifications of the original process. No additional information has been published on the biosorption process developed in Texas and New Jersey. See the last report of this Committee.[126] G. P. Edwards, M. ASCE, reviews the principles of the various modifications of aeration and activated sludge processes and classifies them according to sludge age and purification expected.[149] Where a high degree of treatment is not required, high-rate processes offer savings in first cost and in operation, although more operating data are needed to fully evaluate and compare the various modifications with the conventional activated sludge process.

R. H. Gould, M. ASCE, reports on sewage aeration practices in New York City.[150] New York has developed three modifications of the activated sludge process: (1) step aeration; (2) modified aeration or high-rate activated sludge; and (3) activated aeration. Step aeration yields a final effluent equal to that of conventional activated sludge but requires only about one-half the tank capacity. In this method, sludge returned from the final settling tanks is introduced at the head end of the aeration tanks in the conventional manner but as it flows through the aeration tanks, settled sewage is added to it at several different points. After successive dilutions, the aerated mixture passes to the final settling tanks. Exactly the same weight of activated sludge solids are maintained in the aeration tanks as would be required under the conventional process, usually at a sludge age of some 3.5 days. Inasmuch as higher suspended solids concentrations are maintained at the head end of the aeration tank, stepping down to normal concentrations at the effluent end, the average concentration of solids may be twice that in conventional practice. This explains why only one-half the tank capacity is required. Air requirements are no more and may be less than the conventional process. Results reported for 5 plants where the step-aeration process has been used in New York City indicated BOD removals ranging from 87 to 97% with air consumption from 0.49 to 1.05 cf per gal. in an aeration period of 2.4 to 4.7 hrs., with a sludge age of 3.4 to 5.7 days, and with a suspended solids concentration in the aerator effluent of 900 to 1100 ppm.

The second development, modified sewage aeration or high-rate activated sludge, yields results intermediate to plain sedimentation and full activated sludge. It has the same flow pattern as conventional activated sludge in that returned sludge from the final tanks and all of the sewage are introduced together at the head end of the aerator. The essential difference is that the solids in the aeration tank are kept at an unusually low level, with a sludge age of 0.2 to 0.5 days compared with about 3.5 days in conventional activated sludge. Air requirements are about one-half that for the conventional process.

The third and newest development, activated aeration, is for use in parallel with full activated sludge. It consists of introducing waste sludge from an activated sludge battery to the head of another battery and aerating it there with sewage. The excess sludge from the activated sludge battery and that accumulated in the activated aeration battery is not returned, but concentrated and removed. In parallel operation at the Ward's Island plant, step aeration, modified aeration, and activated aeration gave the following results: BOD removal, 95%, 68%, and 76%, respectively; with air ratios of 0.61, 0.29, and 0.19 cf per gal., respectively; and with aeration periods of 2.7, 2.7, and 2.8 hours, respectively. Mr. Gould states that the methods for intermediate treatment are relatively new and their full possibilities limitations and methods of control have not yet been completely explored but they are already saving New York City millions of dollars in construction and operating costs. A. H. Chasick describes the activated aeration process in more detail with additional data indicating higher BOD removals of 85% or more.(198)

In a companion paper, N. E. Anderson, M. ASCE, discusses sewage aeration practice in The Sanitary District of Chicago.(151) Chicago uses straight aeration tanks with spiral flow, equipped with diffuser plates of 80 permeability. The air usage ranges from 0.35 to 0.69 cf per gal. of sewage. The highest possible degree of treatment is required in Chicago because of limitations of dilution in the water course which receives the effluents. The tidal waters receiving New York City's effluents, however, provide more latitude as to degree of treatment and permit the use of the modified activated sludge processes developed there.

C. E. Keefer, M. ASCE, and J. T. Meisel present studies on sludge age and its effect on the activated sludge process.(152) The age of activated sludge is indicated by its oxidation-reduction potential. F. E. Nussberger discusses applications of oxidation-reduction potentials to the control of sewage treatment processes.(153) R. E. McKinney, A.M. ASCE, and L. Poliakoff in bottle experiments studied the effect of biocatalysts such as concentrated bacteria or concentrated enzymes on activated sludge.(154) The use of such biocatalysts do not increase the rate at which biochemical equilibrium was reached in a new activated sludge system over that of a sewage seeded control system, nor did they increase the rate of BOD removal once equilibrium was reached. The authors conclude that the use of the biocatalysts studied will not increase the efficiency of plant operation in activated sludge systems designed and operated according to biological principles.

Chlorination

The war-time restrictions on the use of chlorine, in effect since January 1951, were removed in November 1952, by the National Production Authority, Department of Commerce.(155) The Joint Committee on Chlorine Supplies (representing the AWWA, the USPHS, the Conference of State Sanitary Engineers, and the Federation of Sewage and Industrial Wastes Associations) issued a report dated August 1953, on recommended procedures in the use of chlorine at water and sewage plants.(156) The committee was formed in 1951 because of the critical chlorine supply situation. In a series of five articles (157), V. W. Langworthy points out the fundamental principles of handling chlorine. J. P. Kavanaugh discusses chlorinator maintenance and operation (158). Bulk storage of liquid chlorine in stationary tanks is described by A. S. Woodward and L. L. Hedgepeth(159) and by B. Benas, M. ASCE.(160) W. W. Sanderson describes a study of sewage chlorination at six plants treating New York sewage.(161) The study showed that for a given residual chlorine content

in the effluent, the coliform count will be dependent upon the amount of sewage treatment provided. Effluents from secondary treatment plants require less residual chlorine than do effluents from primary treatment plants. V. W. Langworthy reports that inactivation of the poliomyelitis virus with chlorine is possible with free residual chlorine although the necessity for the destruction of the virus in sewage is doubtful due to lack of evidence proving poliomyelitis to be a water-borne disease.(162)

B. Benas, M. ASCE, reports that the new San Francisco plants have been able to effect a reduction of 15 to 20% in chlorine dosage by amphoteric chlorine residual control whereby it is possible to obtain a closer control of the rate of feed in relation to the residual chlorine. Post-chlorination has been used in San Francisco but recent studies indicate that pre-chlorination just prior to sedimentation produces equal or better disinfection and at the same time helps control odors in the housed sedimentation tank structures.

Grease Disposal

At the Dayton, Ohio sewage treatment plant grease removal increased considerably in recent years and in 1953 averaged 1,665 lb. per day (dry basis) from a sewage flow of 40 mgd.(196) This material is hauled about one-half mile to the garbage incinerator and burned. Pre-aeration using 0.01 to 0.03 cf of air per gal. together with 1.0 to 1.5 ppm of chlorine increases the grease removal by 10 to 15%.

Sludge Disposal

In this phase of sewage treatment are found the greatest advances of the period. B. Benas, M. ASCE, describes centralized sludge treatment for the three San Francisco plants.(163) L. W. Van Kleeck, M. ASCE, discusses the control of sludge quality in an excellent series of ten articles.(164)

Sludge Digestion

Remarkable advances have been made in sludge digestion during the past two years. Apparently as much as 2/3 of the digestion tank has been inactive as formerly designed and operated. By concentrating sludge prior to digestion (thereby eliminating much of the supernatant liquor problem), by thorough mixing of the tank contents and by frequent feeding of sludge to the digester, it has been found that the digestion process can be greatly accelerated and the time required reduced to a fraction of that formerly considered necessary.

One of the methods used to obtain improved mixing consists of recirculating the digester gas through the sludge mass. This not only allows considerable increase in digester loading but also eliminates most of the scum problem which has been troublesome in digester operation.

Gas recirculation through the digesting sludge was first practiced on a plant scale at Columbus, Ohio(166) and Washington, D. C.(167) Laboratory and pilot plant tests preliminary to the full scale operation at Columbus are described by P. F. Morgan, M. ASCE.(168) Digestion in one-third the normal time or at three times the normal loading is claimed. R. E. Fuhrman, M. ASCE, states that the work at Washington was initiated primarily to find the solution to the scum problem, but appreciable increases in digestion tank loadings were also found possible.

W. N. Torpey, M. ASCE, describes studies on high-rate digestion of concentrated primary and activated sludge in New York City.(169) Torpey also

describes the concentration of combined primary and activated sludges in separate thickening tanks.[170] Combined thickening reduced the unit volume of sludge to be digested by 42 to 64%.

R. G. Coulter, A. M. ASCE, discusses the development of the sludge digestion process and the principal environmental factors necessary for anaerobic digestion.[191] At the new Los Angeles Hyperion plant[81], digester loading rates almost double those anticipated in design have been found feasible. Experimental trials of thermophilic digestion at 120°F. or above resulted in a more filterable sludge but lowered the nitrogen content. Thermophilic digestion is planned for about one-half of the raw sludge and mesophilic digestion at about 90°F. for the other half, mixing the two types when drying for the production of fertilizer. S. S. Baxter, M. ASCE, and H. F. Horlacher describe the submerged sludge heating system at Philadelphia's Northeast Works.[171] The raw unheated sludge is passed through small tanks on the top of which sludge gas is burned in a combustion chamber. The hot products of combustion are discharged directly into the sludge at about 2700°F. at a high velocity. The spent gases at 125°F. are vented through a stack. A new plant at Golden, Colo. with brewery waste constituting about one-half of the total sewage waste treated, uses thermophilic digestion at 130°F. in the primary digester preceded by sludge concentration to from 6 to 12% solids in an air pressure flotation unit.[172] The primary digester is only one-third the conventional size but is insulated with glass wool and cork. G. S. Smith and J. A. Morris discuss the possibility of utilizing reverse refrigeration (the heat pump) to heat sludge digestion tanks.[173]

F. H. Burley, A.M. ASCE, reports that Detroit is odorizing its digester gas as a safety measure to aid in leak detection. The odorizer is a material commonly used with natural gas. After its use was started, several leaks were detected.

Sludge Elutriation and Concentration

A. L. Genter, M. ASCE, reports that the elutriation process was installed or under construction in some 27 sewage plants in the United States and Canada in the past two years. The process is also operating in a few plants in England and Germany. At the primary treatment plant at Baden-Baden, Germany, digested sludge is washed prior to entering secondary digestion and a solids concentration of about 12% achieved. The sludge is again washed after secondary digestion and the solids content increased to 20%, after which it is run onto sand beds to a depth of about 13 inches, where it dries in about 14 days on a bed area of 0.3 sq. ft. per 1,000 persons. The new Wilmington, Del. plant will use interstage elutriation prior to lagooning in a remote marsh area, to wash out chromium and other toxic wastes so that the sludge can digest in the lagoon (74). Interstage elutriation of the supernatant liquor to de-gas and concentrate the solids was used at the Cranston, Rhode I., plant to clear up a problem of dirty supernatant return to the primary settling tanks.[174]

J. F. Laboon, M. ASCE, presents further data on his flotation process of sludge concentration derived from nearly two years of experimental pilot plant work and concludes that the studies have definitely confirmed that sludge concentration by flotation as pre-treatment for incineration is feasible from an operational standpoint, without using vacuum filtration as an intermediate step (175). As stated in this committee's report under "Enlargements of Existing Plants," Charlotte, N. Car., will be the first city to apply the Laboon process (94). Torpey's work on concentration of combined and activated sludges[170] is mentioned in the preceding section of this report under "Sludge Digestion."

The first new sewage works in this country to incorporate the sludge concentration methods as devised by Torpey will be Beaumont, Texas.[176] By use of a sludge thickener, the digester capacity is being cut to 45% of the normal 3.0 cu. ft. per capita requirement of the Texas State Board of Health, which gave its qualified approval. Two-stage digesters will be followed by open-air drying beds.

Sludge Filtration

The control of sludge quality for dewatering is discussed by L. W. Van Kleeck, M. ASCE.[164] C. E. Keefer, M. ASCE, and J. Meisel describe laboratory filtration tests using various chemical coagulants with different types of sludges.[177] Conditioning elutriated digested sludge with lime as well as ferric chloride materially increased the filter cake output. With ferric chloride more than five times more expensive than lime, it was found more economical to use both rather than ferric chloride alone, contrary to the usual practice of filtering elutriated sludges with ferric chloride alone. Keefer also describes a filter cloth washing procedure using water through a high-pressure nozzle (178). F. L. Flood, M. ASCE, discusses vacuum filtration equipment.[179]

Langdon Pearse, M. ASCE, reports that the sixty-six new vacuum filters at The Sanitary District of Chicago Southwest Works have proven satisfactory. The filters are equipped with plastic drainage backing, eliminating the normal wooden drainage strips and wire screen for supporting the filter cloth. The filter drainage piping is also plastic. The filter cloths are secured at the division strips, without wire winding. The subject of filter cloths has been intensively studied and various materials tried. Canton flannel was discarded years ago in Chicago in favor of woolen blankets. Later, tests with nylon showed a much longer cloth life, but at present dacron is favored. All woolen cloths are now being replaced with dacron which has a cloth-life record to date of over 11,000 hours. Treated wool was good for about 3,300 hours, while dynel with 4,000 hours was second only to dacron. The dacron cloth is long-napped on one side and weighs approximately 15 oz. per sq. yd. Dacron has good abrasion resistance and is acid and alkali resistant. While Chicago is changing to dacron cloth for filtering its activated sludge, Milwaukee still uses Canton flannel, and Los Angeles uses wool.

A number of fine-weave synthetic fibre filter cloths have been tried in other sewage plants, but in most instances have not been adopted for regular use. However, W. M. Kunsch reports some interesting results, as yet unpublished, with a coarse-weave saran filter cloth on raw primary undigested sludge at the Waterbury, Conn. Sewage plant, which was able to discontinue the use of ferric chloride and lime, and filter the sludge without chemical conditioning. The saran cloth screen is 32 x 32 mesh, woven from 10 mil monofilament yarn, and is applied to standard vacuum filters in the regular manner with wire winding. For the first six months of 1954, the filter cake averaged 29.3% solids, of which 81.6% were volatile solids. The average filter yield was 6.1 lb. dry solids per sq. ft. per hour. The filter cake is flash dried and then burned in an incinerator along with garbage. The filtrate characteristics changed radically, increasing in suspended solids content from about 100 ppm to 2,000 ppm, while the total solids remained about the same at approximately 3,500 ppm. Suspended solids removal in the settling tanks has not suffered from the change in the filtrate return to the sewage. A few other plants are now experimenting with this coarse filter media. Apparently it is not successful with digested sludge.

Considerable success is being reported with another type of filter media,

the coil spring vacuum filter, in which the filter drum is wound with two sets of coil springs laid in corduroy fashion. Since the first installations at Liberty, N Y. and Mt. Holly, N. J., in 1949, coil spring filters have been or will be installed at some 30 sewage treatment plants up to February 1954, of which the largest installation will be at the new Miami, Fla. plant. Little operating data have been published, but reports indicate successful experience with these filters on both raw and digested sludges, which enabled drastic curtailing or even eliminating chemical conditioning prior to filtration. However, some disadvantages such as wet cake and high solids in the filtrate have been reported. More operating data are needed with various types of sludges and final cake disposal to properly evaluate this new sludge filtration equipment.

Sludge Utilization

Heat-dried activated sludge is still being sold for fertilizer material by the cities of Milwaukee, Chicago and Houston. Baltimore, Md. began heat drying digested activated sludge in 1953 but reports difficulties with fires due to a high grease content. Los Angeles is selling heat-dried digested short-period aeration sludge. San Francisco is selling heat-dried primary digested sludge.

Langdon Pearse, M. ASCE, reports that Chicago is selling its heat-dried activated sludge in bulk carload lots to various contractors on the basis of analysis. The current contract price, for 15% of the output, paid by one buyer is $2.90 per unit of ammonia and 40¢ per unit of available phosphoric acid. Another buyer pays $2.85 and 39¢ respectively, while the third contractor pays $2.235 per unit of ammonia and 36¢ per unit of APA and agrees to pay 60% of any sales he makes in excess of $2.75 per unit of ammonia. The current price paid Chicago for the Southwest sludge is equivalent to about $15.65 per ton (moisture content under 5%).

At Houston, Texas, the heat-dried sludge is sold in bulk carload lots at $3.15 per unit of ammonia and 40¢ per unit of APA, equivalent to a total of about $13 per ton. W. E. White, A.M. ASCE, describes fertilizer production at Houston.[183] The material contains an average of 4.5% nitrogen and 2.8% APA. Houston produced 9,150 tons of fertilizer in 1951 from which a revenue of $121,700 was realized.

Milwaukee now sells its dried sludge entirely in bags, sized from 25 to 100 lb. The base price f.o.b. Milwaukee in 100-lb. bags is $40 per ton, with an allowance to the jobber of $7.25. In nearby states the retail price to the ultimate consumer is about $4.25 per 100 lb.

The County Sanitation Districts of Los Angeles County report 37,784 tons of air-dried sludge furnished in 1953 to the Kellogg Supply Company of Garden Grove for sale to citrus and grape growers. Approximately 4,000 tons of Milorganite were also sold in that area at a price of $4.65 for an 80-lb. bag. Some Chicago sludge was also sold by a jobber in the same area at a retail price of $4.50 for an 80-lb. bag containing 5% nitrogen and 5% phosphoric acid, compared with 6% nitrogen and 2% phosphoric acid in Milorganite. The city of Los Angeles produced 22,626 tons of dry digested sludge in the fiscal year 1952-53 from which a sales revenue of $89,790 was realized, equivalent to approximately $4 per ton.[81] Various other small sewage works in the Southern California area are estimated to produce a total of about 4,000 tons per year which is used locally. At San Francisco, the dried sludge containing about 2% nitrogen and 1.76% phosphoric acid is sold to a contractor who distributes it in bags or bulk. In the fiscal year 1952-53, 21,090 tons of dry material containing slightly less that 10% moisture was produced.[181] The material was sold at $4.37 per ton in March 1953. The dried sludge from both the Los

Angeles and San Francisco plants is so fine and powdery that its market value is reduced. Both cities installed extrusion type pellet mills to make the dried material granular. The dies wore out so rapidly, however, that the pelletizing process had to be temporarily abandoned as uneconomical.[182] The unpelletized material was being sold in 1953 at the Los Angeles plant at a price of $7.00 per ton in sacks and $4.05 per ton in bulk.

After six years of drying sludge for fertilizer, the city of San Diego, California has decided that it is a losing proposition.[185] The contract price for the product has dropped from $20 per ton in 1948 to $6 per ton in 1954. The San Diego City Manager indicated that the completion of the Los Angeles Hyperion plant increased the available supply and affected the marketing of San Diego production. Currently, the production cost per ton is approximately 4 times the amount of revenue recovered. The city is studying alternative methods of sludge disposal to determine which would be the least expensive to the taxpayers.

The new $2 million sludge drying plant for Baltimore, Md. is described by A. R. Vollmer, M. ASCE[184], who estimated in 1951 the sale price of the dried fertilizer should be approximately $10 per ton and that the plant might possibly pay for itself if the sale price equalled or exceeded $12 to $13 per ton. However, recent reports indicate that the Baltimore fertilizer was sold for $6 per ton in 1954. The sales in 1953 were 14,090 tons and 24,093 tons during part of 1954. The material averages 3.37 to 3.89% ammonia and 2.53 to 3.01% APA on a dry basis. Operation has been sporadic because of fire and explosion difficulties.

A. H. Niles reports the sale of 920 tons of Tol-e-Gro sludge fertilizer from the Toledo primary treatment plant in 1953, out of a total suspended solids removal by the plant of 6,575 tons.[186] The revenue received was $12,849, or approximately $14 per ton, as sold in 80-lb. and 25-lb. bags. The Toledo sludge is digested and a portion air-dried in glass-covered beds. The report states: "Since the cost of maintenance of greenhouse structures becomes progressively more expensive, it seems unavoidable that these will have to be abandoned. The whole matter of drying of sludge, preparation and marketing of fertilizer must be examined in the light of present and foreseeable future conditions."

C. E. Irving reports that the rehabilitated Schenectady, N. Y. primary treatment plant began heat-drying digested sludge in 1954, for sale in 80-lb. bags at $1 per bag, equivalent to $25 per ton. See also references[92] and[93].

L. W. Van Kleeck, M. ASCE, discusses the utilization of sewage sludge[187], citing experience in Connecticut. Van Kleeck also discusses fertilizer value in waste disposal methods.[188] A large number of Plant Operators presented a Round-Table discussion on the use of digested sludge as a soil conditioner (189). In most cases, the digested sludge is given away without charge. H. A. Lunt presents the case for sludge as a soil improver.[190] Instructions for conducting sewage sludge field tests are compiled from tests of the Connecticut Agricultural Experiment Station and the New England Sewage and Industrial Wastes Association.[192]

The design engineers for the new Miami high-rate activated sludge plant studied the economics of four alternative methods of sludge disposal[75]:

A. Digestion, elutriation, dewatering, and incineration.
B. Digestion, elutriation, dewatering, and fertilizer production.
C. Dewatering raw sludge and fertilizer production.
D. Digestion, and pumping digested sludge to sea.

Method "D" was the most economical in over-all annual and fixed operating costs but was discarded because of possible local objections in the Miami Beach resort area. Of the other methods, method "A" was the most economical. It was estimated that method "B" was not economical unless a price of $15 per ton f.o.b. plant could be obtained for the heat-dried sludge. As the price of nitrogen at the time of the study was approximately $3.15 per unit and of available phosphoric acid was 40¢ per unit, the sale price of a fertilizer produced at this plant was estimated to be only $7.50 per ton, which would result in a net operating loss to the city of approximately $25,000 annually.

From an economic standpoint alone, it appears that at the present time the production of fertilizer material from sewage sludge is seldom the cheapest method of sludge disposal. However, it does move the material "off the property" and conserves a material beneficial to the soil. Incineration is usually more economical but it leaves a considerable quantity of ash to be disposed of, usually about 30 to 40% of the original dry sludge weight.

Vitamin B_{12} in Sludge

Studies on the possible recovery of Vitamin B_{12} from sewage sludge have continued through the pilot plant stage. Milwaukee sponsored studies leading to the extraction of the vitamin from heat-dried activated sludge, while Chicago sponsored studies on the direct use of heat-dried activated sludge in poultry and pig feeds, thereby eliminating the need for an extraction process for the vitamin.

R. D. Leary in a paper presented at the Ninth Industrial Waste Conference, Purdue University, in May 1954, reports that research on the possible use of Milorganite in animal feeds was started during World War II at the University of Wisconsin. Initially, the study was along the lines of using Milorganite to replace a part of the protein which was in extremely short supply. The University conducted trials with hogs to determine whether Milorganite could serve as a substitute for all or a part of the protein commonly furnished by soybean meal. These feeding trials indicated that hogs could not utilize Milorganite as such as a source of protein. Chick feeding trials were conducted at the same time and assays of the vitamin content of Milorganite were made, showing it to be comparable to yeast in that respect. Because of lack of manpower available at the University to pursue these studies further, the Milwaukee Sewerage Commission in 1945 employed the Miner Laboratories of Chicago to study the dried activated sludge and ascertain what unknown factors were present outside of those used as a fertilizer. Their initial studies concerned fermentation factors similar to those produced by yeast. Then in 1948, the Merck Laboratories and a laboratory in England announced about the same time that Vitamin B_{12} had been isolated and shown to be valuable in animal feeds. Subsequent study by Miner Laboratories indicated that Milorganite is one of the richest sources discovered for Vitamin B_{12}, containing 1 to 4 milligrams of Vitamin B_{12} activity per pound. Research was then concentrated on the extraction, concentration and isolation of Vitamin B_{12} from Milorganite. Processes developed in the laboratory were successfully used in small pilot plant operation, followed by a major pilot plant in which Vitamin B_{12} concentrate of relatively high potency was obtained.

In 1952, the Milwaukee Sewerage Commission engaged the Vern E. Alden Company of Chicago to make a preliminary engineering estimate of costs for an extraction plant that would be constructed adjacent to the Milorganite storage building. The company submitted cost figures for plants to produce concentrates either as a 15% solution, a 40% solution, or a spray-dried powder.

Costs were figured on amortization periods of five years, three years, or one year. A legal question then arose as to whether the Sewerage Commission had power to authorize the use of public funds on a commercial undertaking that was not necessarily a part of the sewage treatment process.(193) The Commission decided that it was not in the public interest to invest public monies in such a venture but private interests should be sought that would risk the money necessary to build an extraction plant and develop a market for the product.

On June 1, 1953, the Sewerage Commission and the Vern E. Alden Company entered into an agreement on a plan for undertaking the vitamin business. Under this plan, the Alden Company constructed a pilot plant at Northwestern University which operated continuously for six months and produced representative quantities of B_{12} concentrate in both the extraction and dry powder form. The pilot plant operation also included re-drying the Milorganite after extraction. Tests indicated the re-dried Milorganite had lost none of its fertilizer quality. Grasses and green crops do not require the Vitamin B_{12} which was extracted from the Milorganite. If the market for this vitamin concentrate is proved to be adequate, the Alden Company will proceed with the construction of a $750,000 plant at the Sewage Works. Briefly, the extraction process consists of multiple-effect washing with constantly weaker solutions of extract, concentration in vacuum evaporators to a syrup and possible spray-drying of the syrup. The air-dried product is a light tan powder with an odor like caramelized sugar. The extracted Milorganite is re-dried in a rotary drier. If it is decided to proceed with the erection of a commercial plant, the entire production of Milorganite may not be extracted but only a sufficient amount to meet current market demand. The U. S. Food and Drug Administration has indicated that it will not object to the use of these vitamin concentrates in animal feeds, nor the use of crystalline Vitamin B_{12} materials prepared from Milorganite for human nutrition or medical purposes. The Alden Company expects to decide by the end of this year as to whether or not it will proceed with this project. If a favorable decision is reached, it certainly will be a novel and interesting venture in the utilization of sewage products. The Sewerage Commission is to get 35% of the net profits before taxes on earnings of the company.(194) At present, Milorganite sales yield a gross revenue of about $2,400,000, or about 60% of the cost of operating the entire sewage treatment plant.

In a paper presented at the Central States Sewage and Industrial Wastes Association meeting in June 1954, Dr. B. Wolnak of the Miner Laboratories stated that digested sludges (primary or activated) do not contain enough B_{12} for economical recovery. About one mg. of B_{12} can be recovered from each pound of Milorganite. At current prices, this is worth about 1¢ per mg. for each pound as Milorganite but about 4¢ per mg. as Vitamin B_{12} (3¢ wholesale).

Since the last report of this Committee(126), the price of Vitamin B_{12} has dropped from $350 to $245 per gram. Early in 1951, it was $595 per gram.

Langdon Pearse, M. ASCE, reports that The Sanitary District of Chicago sought to avoid the expense of extraction of Vitamin B_{12} and therefore studied the use of heat-dried activated sludge in pig and poultry feeds. The investigation started at the University of Illinois in May 1952, under the direction of Professor B. C. Johnson. In the early tests on young pigs, a concentration of 10 to 15% dried sludge in the feed proved too great but a 6% ration was eaten well without any apparent harmful effects. Later tests showed that 2% or less of sludge was ample to stimulate the growth of pigs and that it gave some pigs more weight than when pure B_{12} was used. The optimum amount of sludge

proved to be 5%. In commercial practice, several carloads of the dried activated sludge from Chicago have been used in feed rations for hogs with good results. Other commercial tests have been made with 5% sludge in chicken feed with excellent results. The commercial demand for swine, poultry and turkey feed is about 20 million tons per year. If all this were fortified with 2% of dried activated sludge, it would consume about 400,000 tons of dry sludge per year, or approximately twice the combined production at Chicago and Milwaukee. Professor Johnson is also studying the amino-acid content of activated sludge to determine more accurately whether the protein will also be available as feed material.[195]

Sludge Lagoons

A few large cities dispose of part or all of their sewage sludge in lagoons where conditions are favorable, although in most cases lagoons are regarded as temporary expedients. Such cities include Chicago, Indianapolis, Akron, Toledo, Philadelphia, Baltimore, Houston, Dallas, and Winnipeg. In a paper presented before the Canadian Institute on Sewage and Sanitation in November 1952[197], N. S. Bubbis and D. L. McLean describe the experimental lagoons at Winnipeg. In past years, the primary treatment digested sludge has been elutriated, filtered, and the sludge cake conveyed to a dump. The cost of ferric chloride in Winnipeg increased from $86 per ton in 1940 to $176 per ton in 1952. Faced with such rising costs and the necessity for expanding the existing facilities, the Winnipeg Sanitary District constructed some experimental lagoons and drying beds as described in the last report of this Committee [126]. The following tentative conclusions have been reached:

1) Under Winnipeg conditions, the sand beds will handle four loadings per year and can be used during the summer season only. The high construction cost and the large area required prohibit their use in Winnipeg.
2) The use of under-drains with lagoons is not practical.
3) At least two years will be required before the sludge could be removed from the lagoons.

The experimental operation of the sludge lagoons was continued through 1953. As a result of the data obtained, the consulting engineers recommended that the basic method of sludge dewatering for Winnipeg should be by the use of lagoons, but in order to assure successful operation under all conditions and to give the desired flexibility, the installation of additional elutriation and vacuum filter facilities was also recommended. These recommendations were approved by the Sanitary District Board in January 1954.[95] Four new digesters in addition to the original four are already under construction with completion expected by the end of the year.

Wilmington, Dela. will dispose of elutriated raw primary treatment sludge in a remote marsh area.[74]

Dual Disposal of Garbage With Sewage or Sludge

The dual disposal of garbage with sewage continues to grow and has been stimulated considerably since the last report of this Committee (September 1952).[126] A nation-wide spread of the swine disease vesicular exanthema occurred in the summer of 1952. At that time only six states had legislation or regulations requiring the cooking of garbage prior to use as hog feed[199], but by August 1954, 43 states had laws forbidding the feeding of uncooked garbage to hogs.[200] As a result, many hotels, restaurants and food processing

establishments are installing garbage grinders discharging to municipal sewer systems.

The installation of household garbage grinders has also been stimulated by the large population growth in urban areas, which have increasing difficulty in finding suitable space for garbage disposal by sanitary land-fill. Some of these communities are enacting ordinances requiring the installation of home garbage grinders or incinerators in all new construction. Included among these are Dearborn, Allen Park and Royal Oak in Michigan; Aurora, Colo.[201]; St. Paul, Minn.; South Pasadena, Pomona and Beverly Hills, Calif.[202] In South Pasadena, when a garbage grinder is installed the owner may be granted a waiver of the 60-cent monthly charge for garbage collection.[203] Experience at Dearborn is described by H. A. Hoxie.[204] The National Electrical Manufacturers Association reports that the total number of garbage grinders sold for household use from 1947 thru 1953 was 1,715,000 units. The USPHS reports an average annual increase of 35.3% in the output of garbage grinders for the period 1947 to 1951.[43] By comparison, the annual increase in the output of washing machines averaged 7.5% for the period 1940 to 1951. H. B. Gotaas, M. ASCE, estimates that by 1975 probably 65 to 75% of household garbage will be ground and discharged into the sewer.[205]

In the early part of 1953 Los Angeles was reported to have approximately 80,000 garbage grinders in operation in an area of 2 million population representing about 650,000 families, or one grinder for every eight families.[206] Cleveland reports grinder installations at the rate of about 2,000 per year, with a total of 15,000 to 20,000 in a population of 915,000, or one grinder for every 15 families. About the same ratio prevails at Oklahoma City. Detroit has about 20,000 grinders tributary to its sewer system, or one grinder per 23 families. Grinder permits are being issued by the city at the rate of about 2,500 per year. Indianapolis reports a grinder for one family in 24; Minneapolis reports one in 26; and Washington, D. C., one in 30.

With increasing concentration of garbage grinders, a few reports have been received of deposits in sewer lines. F. R. Bowerman, J.M. ASCE, reports that some deposition occurred in lateral sewers which have grades equal to or less than 0.24% in several large Los Angeles sub-divisions equipped 100% with garbage grinders. He believes grades of 0.4% or better for 8 in. sewers will largely eliminate this occurrence. Rapid generation of sulfides occurs in sewers having deposits of ground garbage. Minor troubles with grease, presumably from garbage, have occurred at pumping stations with clogging of comminutor openings and build-up of grease on pump impellers. More frequent cleaning of the flat sewers are necessary.[81] Long Beach, Calif. has flat sewer grades and also reports deposition of garbage grindings.[207] The grindings deposited in the line cause accumulations of settleable solids, generation of hydrogen sulfide gas, large deposits of grease, and stoppages. Analysis of material cleaned from a sewer laid on flat grades in localities where garbage grinding units predominate, showed a content of 12% bone, 38% egg shells, and 50% sand, ground glass and other materials.

Community-wide installation of garbage grinders as at Jasper, Ind., has been followed by a few others, including Herrin, Ill.; Shorewood Hills, Wis.[208]; S. Euclid, Ohio; and Mt. Dora, Fla.[201] The USPHS presents a detailed report of the Jasper, Ind. project which was begun in December 1949.[209] The report covers the period from March 1950 to October 1951. At that time, over 900 grinders had been installed serving 75% of the population of 5200 persons. The report indicates no noticeable increase in residential water consumption. There has been considerable increase in grease; increase in

suspended matter has varied, while the BOD increased from 0.12 to 0.18 lb. per capita during dry weather.

The use of central garbage grinding stations with disposal to sewage and sludge is exemplified in Canton, O., Lansing, Mich., and Richmond, Ind. In Canton the garbage is ground in the central plant and mixed with the sewage before receiving treatment in a 20 mgd activated sludge plant.[210] The sludge is digested. At Lansing, Mich. the garbage is ground at the sewage plant and discharged into the digesters.[211] Gas is produced at the rate of 3 cf per capita per day, the large production being attributed to the ground garbage. W. E. Ross, M. ASCE, describes the dual disposal of garbage and sludge at Richmond, Ind.[212] This 12 mgd activated sludge plant serves a population of approximately 40,000 and is provided with digestion capacity of 10 cf per capita based on 60,000 population. The garbage is trucked to the plant and sorted before grinding. The ground garbage is pumped to the digesters and the digested sludge is disposed of in liquid form by hauling to farm lands in a 1,500 gallon tank truck at a charge of 15¢ per mile round trip. The garbage collected averaged 0.35 lb. per capita per day in 1952, or one ton per mgd sewage. The dry solids in the sewage sludge averaged 421,000 lb. per month, to which the garbage added an average of 101,000 lb. per month, making a total of 522,000 lb. dry solids per month to the digesters. Gas production was 8.2 cf per lb. of volatiles. The results for the first two years of operation were satisfactory and indicate that the digester capacity of 10 cf per capita was justified.

The city of Philadelphia enacted a code covering the use of garbage grinders.[213] The code covers the construction and installation of the grinder and specifies maximum sizes for the ground garbage. Installation permits are required.

Several alternative methods of garbage and rubbish disposal for the city of Madison, Wis. were studied by Greeley & Hansen.[214] Total annual charges including collection, operation, and fixed charges totaled $454,556 for disposal by incineration, $379,972 to $616,259 for disposal by land-fill, $495,922 for garbage grinding to sewers, and $450,821 for garbage grinding at the sewage treatment plant. The land-fill method was recommended although it was also recommended that land should be set aside for possible future construction of incinerators.

Composting of garbage with other refuse, manure or sewage sludge continues to receive considerable study. Operation of the Compost Corporation of America's Oakland, California Plant was suspended in the Fall of 1952 for redesign and expansion of the plant at an expected cost of $180,000. The new facilities are to handle 225 tons of garbage and produce 100 tons of salable compost per day.[215] No further reports on this plant have been received.

The Frazer, Long Island Compost Corporation produced up to 10 tons of compost daily in a 7-day aerobic fermentation process in a $100,000 plant at Bay Shore, New York.[216] A compost selling price of $68 per ton was reported. The Bay Shore plant is the first full-scale installation of the Frazer-Eweson process, smaller installations having been operated in Mount Wolf, Pa. and Union Stockyards, Chicago, both since abandoned. The fresh garbage is sorted and ground and then dropped into a 14-ft. square by 40-ft. high digester, along with some manure or sewage sludge. Seven days later it is shoveled out at the bottom, sifted and dried. There are four zones of digestion separated by steel grates. Air is passed up through the digesting material. Ten per cent of the finished product is used to seed new batches. The finished product contains 30% moisture. No other analysis is given. Operating difficulties soon

developed, however, and production dropped to only 3 to 3-1/2 tons per week. The trouble appeared to be mechanical difficulties in dropping the garbage from zone to zone down through the digester.[217] Eweson has described his process[218], and believes that compost must be of much higher quality than the presently known product in order to justify the relatively high cost of transportation, bagging and handling. By modifying his process, he hopes to produce a compost "as high as" 2-1/2% nitrogen, 5% phosphorus and 3% potassium on a 25% moisture basis.

The city of Milwaukee considered composting its garbage but decided it was not economically feasible at the present time.[219] The city investigated the processes used by the Compost Corporation of American at Oakland, Calif.; the Frazer-Eweson process at the Chicago Stockyards; and the American Compost Company at Lansing, Mich. The Compost Corporation of America estimated that a plant for Milwaukee would cost about $250,000 per 100 tons of daily capacity and would require 10 to 20 acres for the compost piles. The cost of producing compost ready for commercial sale at Oakland was reported at about $35 per ton.

R. R. Kennedy, M. ASCE, believes that successful composting is primarily a problem of material handling and these mechanical problems have not yet been solved.[220] He believes that inorganic nitrogen, phosphorus and potassium will have to be added to the compost. P. H. McGauhey, M. ASCE, and H. B. Gotaas, M. ASCE, describe two years of research at the University of California on the practice and fundamentals of composting.[221] The process used in the California studies involves segregating, grinding, stacking, turning, and re-grinding the refuse, somewhat similar to that used at Oakland except that no outside inoculum is used. It was found that seeding with an outside inoculum is not an essential part of a practical process for composting municipal refuse. The conclusions of Messrs. McGauhey and Gotaas are significant:

> "There seems little likelihood that composting can be expected to pay the cost of collecting and transporting refuse. In many large cities, for example in New York, it is possible that space requirements and distance from markets for the product might rule out the process altogether. But there is good reason to believe that a process such as defined by these studies offers an economical and sound solution to the refuse disposal problems of many communities, at the same time reclaiming a material of immense value to agriculture."

Analysis of the compost made in this study indicated a nitrogen content ranging from 0.9 to 2.0%, a phosphorus content ranging from 0.60 to 2.29%, and a potassium content of 0.51 to 4.52%. The moisture content is not given. Obviously such material is a very low grade fertilizer and more properly should be called a 'soil conditioner." The work at the University of California is also described by P. H. McGauhey, M. ASCE, and C. G. Golueke.[222] C. G. Golueke and H. B. Gotaas, M. ASCE, discuss the public health aspects of waste disposal by composting.[223] No public health hazards are anticipated with proper operation of the composting process.

At the 59th Annual Congress of the American Public Works Association in October 1953, a symposium was presented on composting as a method of garbage disposal.[224] J. R. Snell, A.M. ASCE, presented the fundamentals of composting with a brief historical review of the various processes developed to date. R. P. Stovroff discussed operational problems in composting and presented a forecast of operations for the expanded Oakland plant of the

Compost Corporation of America. M. S. Anderson discussed the economics of composting from the viewpoint of a chemist in the U. S. Department of Agriculture. Although recognizing the fragmentary data available, Anderson concludes: ". . . There would seem to be no hope of producing these materials for wide use on farm crops. Gardeners may welcome garbage composts that serve their particular needs. . . . There may be a place for chemically fortified composts in certain markets. . . . It should always be kept in mind that chemical nitrogen is much cheaper than this element in any one of the various organic forms."

This Committee after perusal of the references can only conclude that there is still an absence of responsible data on the economic facts of composting. As yet there is no commercially successful composting operation in the United States.

Enzymes and Biocatalysts in Sewage and Sludge Disposal

During the past two or three years the use of enzymes has been promoted to alleviate many of the troubles that beset sewage treatment works. Their use has developed controversy in respect to resulting benefits. In an attempt to evaluate some of the claims and counterclaims, a Special Committee of the California Sewage and Industrial Wastes Association investigated the use of these substances locally and reported its findings in May 1954.[225] J. E. McKee, M. ASCE, Chairman, based his Committee's report on a review of the literature and on questionnaires returned from 18 members with actual experience in the use of these products. A biocatalyst is a substance that activates or stimulates a biochemical reaction. Foremost among the biocatalysts are the enzymes that are produced by bacteria to break down complex substances. The biocatalytic additives that are being proposed for waste treatment are reported to contain concentrated mixed enzymes, preserved microorganisms, and/or some trace minerals. Five different products had been tried in California, selling at a price of $3.00 to $4.95 per lb. Despite the fantastic claims made for some of these products by their manufacturers, the committee tentatively concluded that these same enzymes are normally present in waste treatment processes in concentrations far greater than the recommended dosages of additives would provide; the addition of biocatalytic substances in properly designed and operated plants will produce no benefits; additional enzymes are not indicated for sewers or pumping stations as a means of reducing odors or hydrogen sulfide formations; the majority of evidence indicates that biocatalytic additives will not improve sludge digestion, altho it is possible that the enzymes may exert beneficial action on scum blankets or grease accumulations; biocatalytic additives may improve the performance of oxidation ponds, especially during initial operation. The committee recommended that the investigation be continued and that controlled experiments be conducted by recognized authorities to determine the effects of these substances on various unit processes in waste treatment.

R. E. McKinney, J.M. ASCE, and C. N. Sawyer present a critical review of the use of enzymes in sewage treatment.[226] They conclude that even where the products have been used with limited success, there is some question as to the economics of use and at present there is considerable doubt as to the value of such commercial products. Good design and operation should prevent most of the problems for which enzymes are claimed to be a solution. H. Heukelekian and M. Berger studied the effect of enzyme additions in promoting digestion but found little value therefrom.[227] R. E. McKinney, J.M. ASCE, presents the fundamental biochemistry of waste disposal and the effect of

biocatalysts on activated sludge[228], finding little benefit therefrom. A few favorable reports on the use of enzymes have been published, claiming improved digestion at Houston, Texas[229]; San Leandro, Calif.[230]; Hanford, Calif.[231]; Modesto, Calif.[232]; Borger, Texas[233]; and a few other plants in Texas[234]

Industrial Wastes

The excellent review of the Research Committee of the Federation of Sewage and Industrial Wastes Associations devotes an entire section to the subject of industrial wastes, covering cannery, dairy, packinghouse, fermentation, pharmaceutical, chemical, textile, tannery, coal, coking and gasworks, pickling, plating, petroleum, pulp and paper, and steel wastes, citing some 191 references.[6] While the Federation industrial waste review is very comprehensive, this Committee would like to mention a few items of special interest.

One is the publication of two textbooks on industrial wastes, respectively prepared by E. B. Besselievre, M. ASCE, et al[235], and Willem Rudolfs, M. ASCE, et al[236], which are worth adding to the reference shelf; also Purdue University has published proceedings of the 8th Industrial Waste Conference [237], including an index to the proceedings of the first eight conferences.

E. B. Besselievre, M. ASCE, describes the effect of various types of industrial wastes on city utilities.[238] Besselievre also discusses the application of trickling filters to industrial waste treatment, giving specific examples for 17 different types of wastes.[239] He also discusses the application of the activated sludge process to industrial waste treatment, again giving specific examples for 17 different types of wastes.[240] G. E. Barnes, M. ASCE, presents a review of the industrial waste disposal problem generally, and cites effective procedures for oil disposal, acid neutralization, steel pickling liquors, cyanide removal, and removal of chromium, copper and other heavy metals. [241].

H. H. Black, M. ASCE, discusses the future of industrial waste treatment, pointing out the need for research, and trends in treatment.[242] A. Pickett, M. ASCE, discusses the pollution of wells and ground water by improper industrial waste disposal in the Los Angeles area.[243] R. W. Simpson and J. J. Samsel list and describe ten steps that should be taken by way of preliminary investigation prior to an industrial waste plant design.[244] W. W. Eckenfelder, Jr., and D. J. O'Connor, J.M. ASCE, discuss the application of laboratory and pilot plant studies and industrial waste surveys to treatment process design [245].

The trend in food processing waste is toward disposal by irrigation. The Department of Soils at the University of Wisconsin reports a study on the use of a packing plant effluent for crop irrigation.[246] Effluent from a packing plant following treatment by primary sedimentation and trickling filters was applied to a 40-acre field seeded with Reed canary grass. The 3-year study showed that 40 inches or more of effluent could be applied; the crop and soil removed virtually all nitrogen, phosphorus and potassium; crop yields were substantially increased; and the coli index of a nearby creek was not increased although the chloride and sodium content was. A discussion by R. A. Webster relates favorable experiences of the Seabrook Farms Co. of Bridgeton, N. J. in disposing of vegetable processing water at about 5.5 mgd to 84 acres of sandy loam through three packing seasons. The results show a good source of water for crops and marked recharge of ground water from which the original water used in the processing plant is taken. In Minnesota, seven land

irrigation projects using overhead spray systems for the disposal of cannery wastes were constructed in 1952, six of which replaced ridge-and-furrow irrigation systems or lagoons.[247] A spray irrigation system using plastic pipe was installed for a cannery at Mt. Calvary, Wis.[248] An advantage of the light-weight plastic pipe was its flexibility, which permitted it to be laid directly on top of the ground and moved to another area as the ground became too saturated to take up the waste.

W. Rudolfs, M. ASCE, and W. D. Hanlon discuss the determination and removal of color from industrial wastes in a series of six articles.[249]

High-rate digestion of packing plant wastes is a noteworthy development. W. J. Fullen describes the pilot plant work at the Geo. A. Hormel & Co. in Austin, Minnesota[250], where it was found that packinghouse wastes can be digested in 24 hours with BOD removals of 95%. Preliminary cost estimates for a plant to treat packinghouse wastes by the anaerobic digestion method indicate savings of 35 to 50% in construction costs and 15 to 25% in operating costs, as compared with the aerobic method of sedimentation and filtration with comparable BOD removals. The process takes advantage of the warm packinghouse wastes. The raw waste is kept in intimate mixture with an acclimatized anaerobic sludge in an insulated digester at 90 to 95°F. W. Rudolfs, M. ASCE, and V. Del Quercia also discuss high-rate digestion of slaughterhouse wastes.[251] Slaughterhouse wastes having BOD values of 1500 to 1800 ppm may be digested at temperatures of 70, 85, and 95°F. with detention periods of 2.25, 1.6, and 1.1 days respectively, and with 90 to 95% BOD removal.

The removal of oils from various industrial wastes has received considerable attention. In addition to gravity separators such as the API (American Petroleum Institute), flotation units have been developed by F. S. Gibbs, Inc., and by Bulkley, Dunton Processes, Inc. (Colloidair), which are used in various industries to recover grease and oil and reduce BOD in suspended matter. G. A. Rohlich, A.M. ASCE, discusses the application of air flotation to refinery waste waters and reports some pilot plant studies indicating that air flotation methods were substantially more effective than additional gravity separation in removing oil from an API separator effluent.[252]

Papers presented at the 9th Industrial Waste Conference at Purdue University in May 1954 (as yet unpublished) indicated satisfactory results in oil recovery by pressure flotation. Soluble oil waste treatment by pressure flotation at the Trenton, Michigan plant of the Chrysler Corp. is described by A. H. Beebe.[253]

Information of fundamental importance in connection with BOD tests on industrial wastes is presented by M. B. Ettinger, R. J. Lishka and R. C. Kroner (254). In this USPHS study of the pollutional characteristics of individual organic materials, in this case, pyridine, which is found in by-product coke and petroleum processing wastes, it was found that the conventional BOD test may not reveal the total material subject to biological attack in the receiving stream. The authors believe that this would also apply to many materials found in process wastes. In other words, laboratory BOD tests may not reveal the true BOD of chemical wastes. The load exhibited in the stream after dilution is the basic measure of pollutional characteristics of a waste.

Methods of treating metal finishing wastes are contained in an excellent 72-page manual prepared by the Metal-Finishing Industry Action Committee for the Ohio River Valley Sanitation Commission (414 Walnut Street, Cincinnati 2, Ohio), priced at $2.00 per copy. Ten methods of cyanide treatment are described and two methods for the treatment of chromium. The manual lists 61 references.

In view of the apparent trend toward application of atomic energy to peacetime uses, the problem of radioactive waste disposal is receiving increased attention. Treatment by trickling filters, activated sludge, chemical coagulation, absorption, and ion exchange have been studied, together with direct disposal by burial in land or at sea. Satisfactory waste disposal in the atomic energy field is still an unsolved problem.

The treatment and disposal of atomic energy waste is discussed by J. A. Lieberman and A. E. Gorman, M. ASCE.[255] The current methods of waste treatment are outlined such as storage in tanks, evaporation, ion exchange, co-precipitation, and crystallization, also ultimate disposal by land burial or at sea. Incineration and gaseous wastes are also considered. W. J. Kaufman, J.M. ASCE, and G. Klein discuss pilot plant studies of radioisotope removal in waste treatment.[256] It was concluded that biological treatment methods have limited application to the concentration of mono- and di-valent ionic radioelements from highly mineral wastes. Chemical precipitation has a greater likelihood of being successful in such cases. The removal of radioactive phosphorus from domestic sewage by the activated sludge process may be rather closely estimated if the carrier phosphorus content of the waste and the organic loading of the aeration tank are known. W. A. Rodger discusses the characteristics and disposal of radioactive wastes from a chemical engineering viewpoint.[257]

J. M. Smith discusses the disposal methods used for solid, liquid and gaseous wastes at the Hanford Atomic Energy Plant to protect the Columbia River [258]. Encasement in concrete, followed by ground or sea burial is utilized for solid radioactive waste material. Gaseous wastes are scrubbed and filtered before discharge through tall stacks. A continuous monitoring program has shown that the Columbia River has always remained safe since the Hanford plant went into operation.

D. C. Hampson, E. H. Hykan and W. A. Rodger describe the operation of an active waste incinerator at the Argonne National Laboratory. The normal burning rate is approximately 17 cf per hour, with a volume reduction from feed material to ash of 95%. The activity of the excess gas from the gas scrubbing train has been consistently lower than that of the normal outside air.[259]

L. M. Reading, E. R. Mathews, C. W. Christenson, and J. F. Newell present a study on the activated sludge treatment of radioactive laundry waste.[260] The activated sludge process was satisfactory for the treatment of a mixture of 15% radioactive waste from the Los Alamos Industrial Laundry and 85% settled sewage. Long aeration periods and filtration of the effluent were used. Plutonium was found to build up a concentration in the activated sludge, however, and all excess sludge from a full-scale plant would require special handling and disposal to prevent the scattering of long-lived radioactive materials to the general environment.

H. S. Miller, F. Fahnoe and W. R. Peterson report on a questionnaire survey of waste disposal practices by 1,027 radioisotope users. Ninety-two per cent of the users indicated waste production to be less than two gallons per day. Sixty per cent indicated activity concentration in the waste at less than one microcurie per gallon. Forty-one per cent disposed of the waste by dilution and discharge to sewers.[261]

The first full-scale sewage treatment plant designed to handle radioactive wastes along with domestic sewage was built for the Atomic Energy Commission's National Reactor Testing Station near Idaho Falls, Idaho.[262] Laundry wastes furnish the radioactive component. The trickling filter plant effluent

will be chlorinated and discharged to a sub-surface disposal field where it will be monitored. A high trickling filter recirculation ratio of 5 to 1 was found to give the most satisfactory over-all absorption of radioactivity. The ratio of domestic sewage to laundry waste is estimated at about 10 to 1. Digested sludge will be dried on open beds. Special handling of the dried sludge may be required.

Financing

A symposium on public works financing by three different methods: service charges, special assessments, and general tax levies, was held at the 58th Annual Congress of the American Public Works Association in Los Angeles in 1952.[263] M. W. Tatlock, M. ASCE, discussed service charges. The use of revenue bonds is now so general that it may be said that they have come of age as a financing mechanism. Sewer charges based on metered water consumption represent the most accurate measure of the relative use of sewage works. The method is faulty, however, in that it does not take into account the benefits to vacant property and to large commercial installations using very little water. Sewer charges established as a fixed percentage of the water bills are perhaps the most numerous. Such charges are used by some cities to finance the entire sewage works; by others for only the operation and maintenance of the treatment plant and sewer system; by others for operation and maintenance of the treatment plant only; and by still others for retirement of the debt service on the treatment plant only. At least 275 cities of over 10,000 population have adopted the use of service charges and eliminated or reduced general tax levies for sewage disposal. Service charges alone, however, do not give a fair distribution of the total annual cost of public services. T. D. Moss discussed the use of special assessments, which are usually used to finance the construction of improvements that specially benefit a limited area, such as trunk sewers, lateral sewers, relief sewers, etc. J. B. Massen discussed the use of general tax levies.

The Committee on Sewage and Sewage Disposal of the American Public Works Association has compiled a useful report on sewage service charges in cities over 5,000 population.[264] The average per capita revenue for 15 cities over 100,000 population was $2.57 per year; the average for municipalities in the other population groups ranged from $3.10 to $3.24 per capita per year. The report includes an analysis of the basis of the charges and lists three communities which impose an extra charge for the use of home garbage grinders. Delaware, Ohio and Quakertown, Pa. increase the sewer service charge by 50%, while Borger, Texas imposes an extra charge of 50¢ per month if a home garbage grinder is in use.

H. Van Der Vliet discusses the method of financing sewage treatment at the Joint Meeting plant serving Rutherford, East Rutherford and Carlstadt in Bergen County, N. J.[265] R. Hazen discusses service charges for industrial wastes treatment.[266] If a surcharge is applied to industrial wastes, it is usually based on an increased strength of the industrial waste over the average sewage for the community. One objection to special charges for industrial wastes of varying strengths is the difficulty of regularly obtaining accurate samples and analyses. As a general rule, industrial wastes that are not unusually strong, toxic or corrosive can be disposed of at less cost through a municipal plant than by means of a separate industrial waste plant. An equitable solution to the problem of cost allocation is almost always possible.

S. I. Zack, M. ASCE, describes experience with sewage works financing in

Pennsylvania under the Municipal Authority's Act of 1954.[267] The paper outlines rate schedules as well as industrial wastes regulations. The state pays a subsidy of 2% of the construction cost of sewage works built since 1937 and of new works ordered by the Pennsylvania Sanitary Water Board. Financial data are presented on eight Authorities.

Richmond, Va. proposes to finance a new sewage treatment plant on a "pay-before-you-go" plan, by an 80% charge on all water bills.[268] Although the money collected is applied to the City's General Fund, it is ear-marked to cover capital construction cost of the proposed $16 million plant and to meet operation and maintenance costs. Construction will begin when the water bill levy has built up a large enough reserve to start. The charge should produce a return of about $1,440,000 annually. New York City offers the largest example of revenue received from a sewer service charge. In 1950 the City adopted local Law No. 67 under which a sewer service charge of 1/3 of the water bill is collected to finance the construction and operation and maintenance of its sewage treatment program. The annual sewer rental revenue is running about $14 million, which is still insufficient to cover the operation and maintenance of the sewer systems and existing treatment works as well as finance construction of new treatment projects as rapidly as desired.[269]

The National Institute of Municipal Law Officers has published a book entitled "The Law of Revenue Bonds," presenting the basic concepts of the law surrounding the issuance of revenue bonds by states and local public corporations.[270] It provides a ready access to citations of cases and writings embracing this field of law, and should be of assistance in preparing for the issuance of revenue bonds.

Respectfully submitted,

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COMMITTEE ON SEWERAGE AND SEWAGE TREATMENT

October 18, 1954

APPENDIX

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c. Discussion of several papers, grouped by Divisions.
d. Presented at the Atlanta (Ga.) Convention of the Society in February, 1954.
e. Presented at the Atlantic City (N.J.) Convention in June, 1954.

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